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ABSTRACTS OF ARTICLES ON
OLIGODYNAMIC STERILIZATION

Project WS 768

1 May 1947

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FOREWORD

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The material which follows is intended to serve as an appendix to a report entitled, "Investigation of Oligodynamic Sterilization," now in preparation. Oligodynamic sterilization is the term given to the practice of rendering microorganisms ineffective in various media by the application of minute quantities of different metals in several forms.

The abstracts presented are from pertinent articles available in United States libraries before March 1947, and were prepared by Ralph G. Berk, Project Engineer (Chemical), Water Supply Branch, Engineer Research and Development Laboratories, Fort Belvoir, Virginia.

The abstracts appear in the order of their publication. Within any given year, they are arranged alphabetically by authors. The underlined abbreviations of the periodicals in which they appeared follow the names of the authors (for the full titles, see the "List of Periodicals Indexed" at the beginning of the volume). The volume, page number, and year of publication, respectively, follow the name of the periodical.

The language of the original paper is stated within the parentheses after the title of the abstract. When a translation into English was made by the author of the paper or by the editors of the periodical, the fact is so stated. Translations from the Russian of Abstracts 197 and 204 were kindly provided by the Translation Section of the U. S. Army Medical Library. Abstracts borrowed from other authors have been so indicated.

LIST OF PERIODICALS INDEXED

Acad. Méd. Bul. Académie de médecine, Paris, Bulletin.

Acta Path. Micr. Scand. Acta pathologica et microbiologica Scandinavica (Nordisk patologforening); Copenhagen.

Amer. J. Dig. Dis. American Journal of Digestive Diseases.

Amer. J. Hyg. American Journal of Hygiene.

Amer. J. P. H. American Journal of Public Health.

Amer. J. Pharm. American Journal of Pharmacy.

Anales de la Asoc. Química. Asociación química argentina, anales; Buenos Aires.

An. d'ig. Annali d'igiene; Rome.

Ang. Chem. Angewandte Chemie; Berlin.

Ann. d'hyg. Pub. Annales d'hygiène publique, industrielle et sociale; Paris.

Ann. Inst. Past. Institut Pasteur, Paris, annales.

Arch. Derm. Syph. Archiv für Dermatologie und Syphilis; Prague, Vienna, Berlin.

Arch. di Sci. Biol. Archivio di scienze biologiche; Naples.

Arch. Exper. Pathol. Archiv für experimentelle Pathologie und Pharmakologie; Leipzig.

Arch. f. Hyg. Archiv für Hygiene und Bakteriologie; Munich.

Arch. f. Schiffs u. Trop. Archiv für Schiffs- und Tropenhygiene; Leipzig.

Arch. Ital. Méd. Sper. Medicina sperimentale, archivio italiano; Turin.

Arch. Mikrob. Archiv für Mikrobiologie; Berlin.

Arch. Path. Archiv für die Pathologie und Therapie; Hamburg.

A. S. P. R. P. Prog. Reps. American Silver Producers Research Project, National Bureau of Standards, Progress Reports.

A. W. W. A. J. American Water Works Association, Journal.

Bact. Rev. Bacteriological Reviews.

Ber. deuts. chem. Ges. Berichte deutsche chemische Gesellschaft; Berlin.

Berl. Klin. Wochs. Berliner klinische Wochenschrift; Berlin.

Biochem. J. Biochemical Journal; Liverpool.

Biochem. J. (London). Biochemical Society, London, Journal.

Biochem. Zts. Biochemische Zeitschrift; Berlin.

Biol. Bul. Biological Bulletin, (Woods Hole, Mass. Marine Biological Laboratory).

Biolog. Ztbl. Biologisches Zentralblatt; Leipzig.

Bol. Inst. Med. Exp. Cáncer. Buenos Aires Instituto de medicina experimental para el estudio y tratamiento del cáncer, boletín.

Brit. J. Radiol. British Journal of Radiology; London.

Brit. Med. J. British Medical Journal; London.

Bul. Hyg. Bulletin of Hygiene; London.

Bul. Sci. Pharm. Bulletin des sciences pharmacologiques; Paris.

Bul. Soc. Belge d'opht. Société belge d'ophtalmologie, Bulletin; Brussels.

Bul. Soc. Chim. Biol. Société de chimie biologique; Paris.

Can. P. H. J. Canadian Public Health Journal; Toronto.

Chem. Age. (London). Chemical Age; London.

Chem. and Ind. Chemistry and Industry; London.

Chem. and Met. Engr. Chemical and Metallurgical Engineering.

Chemisch Weekblad. Amsterdam.

Chem. Ztbl. Chemisches Zentralblatt; Leipzig.

Chem. Ztg. Chemiker-Zeitung; Cöthen.

Cold Springs Harbor Symposium on Quantitative Biology.

Compt. Rend. Acad. Sci. Académie des sciences, comptes rendus hebdomadaires des séances; Paris.

Compt. Rend. Acad. Sci. URSS. Akademiia Nauk S. S. S. R. Comptes rendus de l'académie des sciences de l' U.R.S.S.; Leningrad.

Compt. Rend. Soc. Biol. Société de biologie, comptes rendus hebdomadaires des séances; Paris.

Denks. d. Schweiz. Naturf. Ges. Schweizerische naturforschende Gesellschaft, Denkschriften; Zurich.

Dermat. Zts. Dermatologica; Berlin.

Deu. Med. Wochs. Deutsche medizinische Wochenschrift; Leipzig.

Enzym. Enzymologia; The Hague.

Erg. Enzymf. Ergebnisse der Enzymforschung; Leipzig.

Erg. Hyg. Ergebnisse der Hygiene, Bakteriologie, Immunitätsforschung und experimentellen Therapie; Berlin.

Erg. Vitm. Hormf. Ergebnisse der Vitamin- und Hormonforschung; Leipzig.

Fermentforschung. Leipzig.

Food Ind. Food Industries.

Forsch. u. Forts. Forschungen und Fortschritte; Berlin.

Forts d. Med. Fortschritte der Medizin, Berlin.

Fruit Prods. J. Fruit Products Journal and American Vinegar Industry.

Ges. Ing. Gesundheits - ingenieur; Munich.

Gior. di Bat. e Im. Giornale di batteriologia e immunologia; Turin.

Gior. Med. Mil. Giornale di medicina militare; Rome.

Helv. Chim. Acta. Helvetica chimica acta; Basel.

Hyg. Rund. Hygienische Rundschau; Berlin.

Ind. and Eng. Chem. Industrial and Engineering Chemistry.

Inst. Met. J. Institute of Metals, Journal; London.

Iowa St. Col. J. Sci. Iowa State College Journal of Science.

Irish J. Med. Sci. Irish Journal of Medical Science; Dublin.

J. Allegy. Journal of Allergy.

J. Amer. Chem. Soc. American Chemical Society Journal.

J. Amer. Med. Assn. American Medical Association, Journal.

J. Amer. Pharm. American Pharmaceutical Association, Journal,
(Scientific edition).

J. Bact. Journal of Bacteriology.

J. Biochem. Journal of Biochemistry; Tokyo.

J. Biol. Chem. Journal of Biological Chemistry.

J. Cellul. Physiol. Journal of Cellular and Comparative
Physiology.

J. Gen. Physiol. Journal of General Physiology.

J. Hyg. Journal of Hygiene; Cambridge, England.

J. Infec. Dis. Journal of Infectious Diseases.

J. Lab. and Clin. Med. Journal of Laboratory and Clinical
Medicine.

J. Lancet. Journal-Lancet; Minneapolis.

J. Med. Chir. Prat. Journal de médecine et de chirurgie pratiques;
Paris.

J. of Physiol. Journal of Physiology; London.

J. Path. and Bact. Journal of Pathology and Bacteriology; Cambridge, England.

J. Physical Chem. Journal of Physical Chemistry.

J. Res. N. B. Stds. Journal of Research of the National Bureau of Standards.

J. Soc. Chem. Ind. Society of Chemical Industry Journal; London.

Klin. Wochs. Klinische Wochenschrift; Berlin.

Kol. Chem. Beih. Kolloidchemische Beihefte; (Kolloid-beihefte); Dresden.

Kol. Zts. Kolloid-Zeitschrift; Dresden.

Lancet. London.

Med. Klin. Medizinische Klinik; Berlin.

Med. Wochs. Medizinische Wochenschrift; Berlin.

Mich. Eng. Exp. Sta. Bul. Michigan Engineering Experimental Station, Bulletin.

Mikrochemie. Vienna.

Mikrochemie Pregl. Pregl Festschrift für Mikrochemie; Leipzig.

Mitt. Geb. Lebmtl. Mitteilungen aus dem Gebiet der Lebensmitteluntersuchung und Hygiene; Bern.

Mitt. Grenzgeb. Med. u. Chir. Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie; Jena.

Mitt. Med. Ak. Kioto. Mitteilungen aus der medizinischen Akademie zu Kioto; Kyoto - ikadaigaku - zasshi; Kyoto.

Munch. Med. Wochs. Muenchener medizinische Wochenschrift; Munich.

Natws. Naturwissenschaften; Berlin.

Nav. Med. Assn. Jap. Bul. Naval Medical Association of Japan, Bulletin; Tokyo.

N. B. S. Res. Circ. United States Department of Commerce,
National Bureau of Standards Research Circular.

N. E. W. W. A. J. New England Water Works Association Journal.

"Öfv. a. Finsk. Vets. Soc. Finska vetenskaps-societeten,
"öfversigt af förhandlengar; Helsinki.

Ont. Res. F. Bul. Ontario Research Foundation, Bulletin; Toronto.

Parasitology. A supplement to Journal of Hygiene.

Pathol u. Pharmakol. Pathologie und Pharmakologie.

Pflüg. Arch. Physiol. Pflueger's Archiv für die gesamte Physio-
logie des Menschen und der Tiere; Bomm.

Pharm. Wkbl. Ned. Pharmazeutisch weekblad voor Nederland;
Amsterdam.

Pharm. Ztrh. f. Deu. Pharmazeutische Zentralhalle für Deutschland;
Dresden.

Power

P. P. E. Power Plant Engineering

Prakt. Akad. Athen. Praktika tes Akademias, Athenon; Athens.

Presse Med. Presse médicale; Paris.

Proc. Roy. Soc. London. Royal Society of London, Proceedings;
London.

Proc. Roy. Soc. Med. Royal Society of Medicine, Proceedings;
London.

Proc. Soc. Exp. Biol. and Med. Society for Experimental Biology
and Medicine, Proceedings.

Pub. H. Rep. Public Health Reports.

Pub. Wks. Public Works.

Quart J. and Yrbk. Pharm. Quarterly Journal of Pharmacy and
Allied Sciences; and Yearbook of Pharmacy; London.

Quart. J. Pharm. and Pharm. Quarterly Journal of Pharmacy and Pharmacology; London.

Rev. Asoc. Méd. Arg. Asociación médica argentina, Revista; Buenos Aires.

Rev. d'immunol. Revue d'immunologie; Paris.

Rev. Inst. Bact. Revista del instituto bacteriológico "Dr. Carlos S. Malbran;" Buenos Aires.

Rev. Inst. Salub. Enf. Trop. Insitute de salubridad y enfermedades tropicales; Mexico.

Riv. Biol. Rivista di biologia; Rome.

Schw. Apo. Ztg. Schweizerische Apotheker-Zeitung; Zurich.

Schw. Med. Wochs. Schweizerische medizinische Wochenschrift; Basel.

Science

Sci. Nat. Sciences naturelles; Paris.

Soc. Chem. Ind. Vict. Proc. Society of the Chemical Industry of Victoria, Proceedings; Australia.

Soc. Ital. Biol. Sper. Bol. Società italiana di biologia sperimentale, bollettino; Naples.

Soc. Med. Fen. Duo. Acta. Societas medicorum fennica Duodecim, acta; Helsinki.

Stud Rockf. Inst. Med. Res. Rockefeller Institute for Medical research, Studies.

Suddeu. Molk. "Sueddeutsche Molkerei-Zeitung; Allgau.

Tech. Gemdbl. Technisches Gemeindeblatt; Berlin.

Trans. Assoc. Amer. Phys. Association of American Physicians, Transactions.

Umschau. Frankfurt a. M.

Univ of Calif. Publications. University of California Publications.

U. S. D. A. Tech. Bul. United States Department of Agriculture, Technical Bulletin.

Voenno Med. Zhur. Voenno meditsinskii zhurnal; Leningrad.

Vom Wasser Berlin.

Wat. and Sew. Water and Sewage (Canadian Engineer); Toronto.

Wat. and W. Eng. Water and Water Engineering; London.

Wat. Pol. Res. Sum. Water Pollution Research, Summary of Current Literature; London.

Wien. Klin. Wochs. Wiener klinische Wochenschrift; Vienna.

Wien. Med. Wochs. Wiener medizinische Wochenschrift; Vienna.

Wirchows' Arch. Virchow's Archiv; Berlin.

W. W. and Sewr. Water Works and Sewerage.

Ztbl. f. Bakt. Zentralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten; Jena.

Ztbl. f. Physiol. Zentralblatt für Physiologie; Vienna.

Ztbl. gesam. Hyg. Zentralblatt für die gesamte Hygiene mit Einschluss der Bakteriologie und Immunitätslehre; Berlin.

Zts. anal. Chem. Zeitschrift für analytische Chemie; Wiesbaden.

Zts. Desinf. u. Gesw. Zeitschrift für Desinfektions- und Gesundheitswesen; Dresden.

Zts. f. Chem. u. Ind. d. Kol. Zeitschrift für Chemie und Industrie der Kolloide; (Kolloid-Zeitschrift); Dresden.

Zts. f. Elektrochem. Zeitschrift für Elektrochemie und angewandte Physikalische Chemie; Hall a. S.

Zts. f. Hyg. u. Infek. Zeitschrift für Hygiene und Infektionskrankheiten; Leipzig.

Zts. ges. Krankhsw. Zeitschrift für das gesamte Krankenhauswesen; Berlin.

Zts. ges. Naturws. Zeitschrift für die gesamte Naturwissenschaft;
Brunswick.

Zts. Hyg. Zool. Zeitschrift für hygienische Zoologie und
Schädlingsbekämpfung; Berlin.

Zts. Immunfor. Zeitschrift für Immunitätsforschung und
experimentelle Therapie; Jena.

Zts. Phys. Chem. Hoppe-Seyler's Zeitschrift für physiologische
Chemie; Berlin.

Zts. Unters. Lebsm. Zeitschrift für Untersuchung der Lebensmittel;
Berlin.

ABSTRACTS OF ARTICLES ON
OLIGODYNAMIC STERILIZATION

1. STUDIES OF THE CHEMISTRY OF VEGETATION (in French), Jules Raulin, *Sci. Nat.*, 11:93 (1869). General topic was study of chemical nutrients for vegetation, including microscopic forms. Detailed investigation of influence of mineral salts mixed into media for culture of *Aspergillus niger*. On 16 July 1867, observed effects of AgNO_3 in varying concentrations in medium. "The silver nitrate . . . becomes active with a dose of 0.003 g: 500 g liquid or 1:1,600,000. AgNO_3 gradually becomes inactive after certain number of days because of influence of organic matter in medium. *Aspergillus niger* cannot grow in silver vessels . . . chemical action of liquid medium on metal is transformed in very minute quantities into silver salt which, in turn, reacts on development of vegetation." Found HgCl_2 poisonous in concentrations down to 1:512,000, PtCl_2 down to 1:8,000, and CuSO_4 much less active. Raulin's paper seems to be first record of oligodynamic action of metals on living matter, although term was coined by Nageli later.

2. ON DISINFECTION MEDIA AND METHODS (in German), Emil von Behring, *Zts. f. Hyg. u. Infek.*, 9:395 (1890). (Abstract is cited from V. Horelli.) Investigated effects of various metals and their salts on *Coryn. diphth.*, *mallei*, *B. pyocy.*, *B. anthracis*, and *Vib. cholera*; several metals placed on each inoculated agar or gelatin plate. Found size of sterile zone surrounding test metal varied with kind of metal, bacterial strain, contact time, temperature, and media constituents. Observed residual oligodynamic effect in culture after withdrawing test metal. Seldom found sharply defined sterile zone margins. Believed oligodynamic bactericide caused by dissolution of metal in medium. Used comparison of sizes of sterile zones as criterion for determining relative sensitivity of bacteria and comparative activity of metals. Explained differing activity by supposing different bacterial respiratory products to cause variations in solution of metal. Gave relative activity of metal in following descending order: As, Ag, Hg, Cu, Ni, and Zn; not active, Sn, Pb, and Fe.

3. BACTERIOLOGICAL DISCUSSIONS, VII INTERNATIONAL CONGRESS OF HYGIENE AND DEMOGRAPHY AT LONDON (in German), Max Gruber, *Ztbl. f. Bakt.*, 11:115 (1891). Mentioned existence of interferences in tests of disinfectants; nothing of immediate interest regarding oligodynamic action.

4. CONTRIBUTIONS TO THE BIOLOGY OF THE CHOLERA BACILLUS

(in German), J. Uffelmann, Berl. Klin. Wochs., 29:1209 (1892). (Abstract is cited from V. Horelli.) Smeared liquid Vib. cholera culture on used, clean coins; dried in 5 to 10 minutes. Vib. found dead on Cu coins in 10 minutes, on Ag 5 minutes later, lived longer on brass, 5 hours on Pt, and 23 hours on piece of paper. Could make no explanations for foregoing.

5. OLIGODYNAMIC ACTION ON LIVING CELLS (in German), Karl Wilhelm von Nägeli, Denks d. Schweiz. Naturf. Ges., 33:174 (1893). Nägeli's observation of death of living cells in so-called clean, distilled water, or in well water led him to investigate effects of AgNO_3 on fresh-water algae-Spirogyra. Observed much different change of cell structure when killed by AgNO_3 of 10 ppm than by greater dilutions. Termed former "ordinary" or "poisoning" death, latter "oligodynamic" death. Found death by AgNO_3 in dilutions as great as 10 ppm in 3 to 4 minutes. HgCl_2 showed "ordinary" death at 100 ppm dilutions, which disappeared at 1 ppm dilutions, but "oligo." death persisted at HgCl_2 10^{-24} dilution in 3 to 6 minutes. Repeated tests gave regular results. Detailed investigation of comparative metal activity showed action of Ag occurred much quicker than Au; same true of Pt. "Activated" water with oligodynamic properties by contact with Cu, CuCl_2 , or salts of Ag, or Hg. Such water was deactivated by contact with sulfur, soot, grafite, coke, anthracite coal, peat, filter paper, cotton, linen, wood, silk, stearic acid, and paraffin. Activated walls of glass jar by means of piece of metal suspended in water retained therein. This activity then transferred from glass wall to other inactive water poured into this jar, repeatedly, for several weeks. Boiling of water in jar deactivated walls. Discovered Pb, Zn, Cu, and Fe in residue after evaporating water found to kill Spiro. Concluded that water becomes oligodynamic by absorbing traces of metal from distillation equipment, or by contact with brass valves before drawing from pipes; metal ions adsorbed from water by glass container walls and stored therein, then given up to subsequent non-active water. Removed oligodynamic pollution from glass by washing with solutions of HCl or HNO_3 . Must distill water in glass to obtain neutral water. Precise investigations of Nägeli demonstrated oligo. effect varied with cell species, age of cells, media constituents, state of cell development, temperature, concentration of test metal salt, and with contact time.

6. THE EFFECTS OF VARIOUS METALS ON THE GROWTH OF CERTAIN BACTERIA (in English), Meade Bolton, Trans. Assoc. Amer. Phys., 9:174 (1894). Reviewed work of Nägeli and others. Bolton's work was with infected agar plates and Cu, brass, Ag, Au, Mg, Zn, Cd, Hg, Al-foil, charcoal, Si, Mo, Sb, Bi, Fe, Ni, and Pt. Concluded that metals resisting chemical agents generally showed little oligodynamic action; those easily attacked showed marked

inhibition of bacterial development. Observed around test element in agar, clear, sterile zone bounded by ring of intensified growth. Believed that clear zone indicated presence of great concentration of dissolved metal salts; margin of intensified growth indicated smaller traces of metal may stimulate bacterial growth.

7. ON A SUPPOSED ACTION OF DISTILLED WATER AS SUCH ON CERTAIN ANIMAL ORGANISMS (in English), F. S. Locke, *J. of Physiol.* (London), 18:319 (1895). Locke's work substantiated Nageli's findings and conclusions. Found water distilled in glass non-injurious to tadpoles and tubiflex, while aq. dest. from tin or copper coils was fatal to both. Deactivated oligo. water by contact with magnetic iron oxide, graphite, or $\text{Ca}_3\text{P}_2\text{O}_8$. Also recognized adsorption effect of glass.

8. OLIGODYNAMIC ACTION ON PLANT AND ANIMAL CELLS (in German), O. Israel and Th. Klingmann, *Wirchow's Arch.*, 147:293 (1897). Israel and Klingmann did work similar to that of Nageli. They investigated effect of metals on cell structures of *Spiro. majuscula*, *laxa*, and *crassa*. Described and illustrated in great detail "plasmoschism" or separation of the 2 plasma membranes caused by oligo. action, and plasmolysis caused by ordinary poisoning. After Cu penetrates outer cell wall, protoplasm threads and chlorophyll bands contract, threads tear; small amount of Cu then penetrates plasma membranes where it goes into chemical combination. Further diffusion of Cu brings it to cell interior; death now can occur without any visible change in state of cell substance; plasma streaming ceases, nucleus loses its shape, becomes spherical, and breaks up into various substances. With *Spiro.* and Cu placed in neutral water at same instant evidence of oligo. action appeared within $2\frac{1}{2}$ to 4 hours. In water previously contacted 24 hours by Cu, oligo. action appeared on *Spiro. crassa* in 2 hours, on *majuscula* in $2\frac{1}{2}$ hours, and on *laxa* in $2\frac{3}{4}$ hours. Presented inconclusive data on influence of amount of Cu surface on activity. With certain dilution of Cu activated water, observed same change in cell interior as was produced by strong electric current of short duration. Comparison of effectiveness of metals showed Ag to be slower than Cu. They surmised that different sensitivity of various *Spiro.* caused by differences in structure of outer cell walls; these may have various degrees of wet-ability, therefore, various starting times of plasma disturbance. Viewed "ordinary" and "oligo." death as the same, differing only in degree.

9. THE CHEMICAL BASES OF THE STUDY OF POISONING AND DISINFECTION (in German), B. Krönig and Th. Paul, *Zts. f. Hyg. u. Infek.*, 25:1 (1897). Proposed "standard" method for investigation of disinfection, in which all variables are to be maintained constant for facilitating comparison of test results. No mention was made

of possibility of oligo. pollution of glassware or water. Article deals mainly with disinfection by organic and inorganic substances without any attention to oligodynamic disinfection.

10. ON THE LIFE AND DEATH OF PATHOGENS (in German), Martin Ficker, Zts. f. Hyg. u. Infek., 29:1 (1898). Defined effects on bacteriological examinations by conditions of air, culture media, temperature, etc. Stressed effects of glassware. Cited previous work on determination of amounts of alkali substance absorbed from flasks and beakers of various kinds of glass. Ficker's work indicated Jena glass imparted Na_2O of 0.003 mg/l at 20 C in 8 days, and 0.00515 mg/l at 80 C in 3 hours. Found Vib. cholera very sensitive to "glass action." Explained oligo. pollution of glass caused by low solubility of metals. The Cu particles contacted glass walls, amount of adsorption increasing with use of vessel. Neither frequent brushing nor repeated use of vessel will decrease oligo. pollution of glass. Did deactivate glass by contact with HCl for $\frac{1}{2}$ hour. Demonstrated water kept behind tap 16 hours before drawing, to be bactericidal in 1 hour to bacterial concentration of 255,000/cc. Tap water retained 5 minutes in pipe showed reduction to 7000/cc after 1-hour contact. Working with CuSO_4 on suspension of 24-hour culture of unnamed bacteria, he found evidence of bactericide with CuSO_4 of $1/6 \times 10^{-7}$, and strong bactericide at 10^{-7} dilution. Activated neutral water by retention in vessel of ordinary glass previously used with $1/5 \times 10^{-7}$ Cu solution, and not cleaned thereafter. Claimed that Jena glass had no oligo. residual.

11. THE INJURIOUS EFFECTS OF METALS ON BACTERIA (in German), Hermann Thiele and Kurt Wolf, Arch. f. Hyg., 34:43 (1899). Sought to determine conditions under which pure metals are oligo. Worked with single and various combinations of metals. Used Staph. pyogen. aureus in plated solid cultures. Tested with Au in various forms, coins, and various metals, all carefully prepared by various chemical and mechanical cleaning techniques. Found Au and all coins gave negative results, although some coins showed imperceptible bactericide. No effect with Pt, Pd, Pb, Sn, Fe, Zn, Mg, and Al, but Ag and Hg were bactericidal. As pulverized, found no effect with Au, Pt, Fe, and Al; but Pd, Zn, Cu, and some Mg were active. Investigated effect of metals in combination upon each other. Sought to answer question: Is it possible to increase or decrease oligo. action of Ag by adding or connecting another substance to it? Upon surface of inoculated agar plate placed 2 pieces of dissimilar metal connected to each other by bow of either metal strip, bridging across intervening agar surface. Connection with Au, Pt, or Pd gave considerable increase in oligo. action of Ag as evidenced by sterile zone 5 times larger than from Ag alone. Graphite increased oligo. power of Ag, but imparted

none to Au, Pt, or Pd. Pt increased oligo. power of Hg when bound together. Similar results were obtained with mixtures of powder of same elements. Fineness of powder made no difference. Noted strong activation with very small amounts of powdered activating element. Manner of action likened to that of electrolyte cell in which nutrient medium is electrolyte fluid with its NaCl content acting as electrolyte; dissimilar metal plates act as electrodes, and when connected by bridge conductor, closed electric circuit is provided. Direction of current depends upon position of each metal in electromotive series. Thus Ag becomes more oligo. when contacted with relatively electro-negative Pd, Pt, Au, and C; current flows to Ag. Presence of dark brown color in agar around Ag plate after its removal indicated that Ag went in to solution there. Three tests with such metal pairs contacting inoculated agar plates $\frac{1}{2}$ hour, then incubated 24 hours at 37 C showed sterile zones around Ag plates. Believed this to indicate that oligo. action of metals is not influenced by action of bacterial waste products. Found sterile zone around Pt when bound to Zn or Fe, around Au when bound to Al or Fe, and around Pd when bound to Fe. They felt that absolutely pure metals are non-oligo., and become so only by presence of minute quantity of other element as impurity. Chemically pure metal is impossible in practice.

12. SOLUBLE SILVER AS INTERNAL ANTISEPTIC (in German), Karl S. F. Credé, Berl. Klin. Wochs., 38:941 (1901). Credé's work on comparative oligo. activity of metals indicated following descending order: Tl, Cd, Cu, Ag, and Au with no bactericide evidenced by Al. Ag leaf placed on inoculated culture or infected wound disappeared after few days, but not on non-infected wound. Upon examination of sterile zones produced in agar by Ag, found Ag salts, and near bacteria therein found Ag-lactic acid compounds. Therefore, oligo. action of Ag caused by dissolution of metal by bacterial waste products. Balance of paper dealt with therapeutic application.

13. ACTION OF COLLOIDAL AND ELECTROLYTICALLY DISSOCIATED METAL SOLUTIONS ON CELLS (in German), G. Galeotti, Biolog. Ztbl., 21:321 (1901). Galeotti referred to findings of Nageli in regard to "oligo." death and to the work of Israel and Klingmann in regard to "plasmoschism." He believed these merely preliminary stages of eventual plasmolysis of cells in hypotonic solutions. Investigated comparison of effects of colloidal Cu and Cu ions in CuSO_4 solution, on *Spirogyra nitida*. Meticulous work, careful of extraneous contaminations, over period of 5 months, with very regular results; careful microscopic examinations. Morphological changes occurred in 30 minutes for high concentrations of colloidal Cu but sooner for Cu ions. At greater dilutions plasmolysis occurs at same time for both. Cu ions penetrating into cell

combine with protoplasm molecules, thus poisoning cell. Train of events in cell is as follows: (1) weakening of cell membranes and equalizing of osmotic pressures with entry of water, (2) plasmolysis or breaking up of protoplasts, tearing of protoplasm chords, clumping of chromophores, (3) plasmolysis or dissolution of protoplasm membranes, and agglomeration of all cell substances, protoplasts, chromophores, and nucleus into center of cell. With colloidal Cu catalytic action occurs on metabolic processes of cell, speeding them up, disturbing life so greatly as to lead to death.

14. COLLOIDAL SILVER-OXIDE (in German), C. Paal, Ber. deuts. chem. Ges., 35:2206 (1902). Was study of organic chemistry of heavy metal salts and proteins, their complexes, their solubility characteristics. It had been assumed previously that heavy metal is not retained in protein molecule as ion but in so-called organic bond. Paal demonstrated, however, that metal as hydroxide is retained or absorbed by alkali solutions of protein substances like protalbin acid or lysalbin acid.

15. ON THE SO-CALLED METAL-ALBUMINOID COMPOUNDS AND THE THEORY OF CHEMICAL EQUILIBRIUM (in German), G. Galeotti, Zts. Phys. Chem., 40:492 (1903). In his summary, Galeotti stated that between heavy metal salts and albumin, no combinations occur with real dependence on valence theory. So-called metal albuminate precipitates from mixtures are seen to be loosely bound in varying proportions. These precipitating processes are reversible; precipitates dissolve in excess of either original component. Combination of precipitate depends upon combining of solution still in contact with precipitate, as governed by thermodynamic laws of chemical equilibrium. Showed graphic analysis for equilibrium problem of egg, or serum albumin with CuSO_4 , or AgNO_3 at 14 to 16 C.

16. "N" RAYS (in French), R. Blondlot, Pamphlet published by Gauthier-Villars, Paris (1904). While he was studying x-rays Blondlot observed some totally different ones which he named "N" rays. Also observed them to issue from piece of Ag when made red hot in Bunsen burner. These emerged from upper surface of metal when held in flame 45 degrees to horizontal. Wave lengths run from 30A to 80A. Substances under compression are spontaneous and permanent sources of "N" rays.

17. ON THE TOXICITY OF DISTILLED WATER FOR THE FRESH WATER GAMMARUS (in English), G. Bullot, Univ. of California Publications Physiol., 1:199 (July 31, 1904). Observed distilled water, and water in ordinary and Jena glass was toxic to Gammarus.

18. RELATIONS OF THE METALS OF THE COPPER GROUP TO CELLS OF LOWER PLANTS (in German), Th. Bokorny, Ztbl. f. Bakt., 16:267 (1906). Observed that only 3 metals of the Cu group, Cu, Hg, and Ag, can be bactericidal in low concentrations of 10^{-7} . Non-injurious to *Spirogyra* were Pb salt at 15^{-5} after 4 days, iron-sulfate at 10^{-4} for 6 days, FeCl_3 same; analagous results for salts of U, Zn, and Cd. Believed that copper group metals react with protoplasmic albumin in sufficient quantities to be injurious.

19. USE OF METALLIC COPPER FOR WATER PURIFICATION (in English), H. Kraemer, Amer. J. Pharm., 78:140 (1906). Investigated action of Cu on *Vib. cholera* and *B. typhi*. Proposed use of Cu for sterilizing drinking water. Kraemer's paper contained no test data.

20. ACTION OF COLLOIDAL SILVER ON SOME PATHOGENIC MICROBES (in French), Mlle. P. Cernovodeanu and Victor Henri, Compt. Rend. Soc. Biol., 61:122 (1906). (Abstract is cited from V. Horélli.) Investigated chemically pure, colloidal metals: Ag, Pt, Au, Pd, Cu, Mn, Cd, Hg, etc. Activity varies with fineness of metal particles in suspension. Required 1:50,000 of colloidal Ag to kill *Micro. pyogen.*, *B. anthracis*, and *B. typhi*; but *B. coli* showed no sensitivity.

21. DISINFECTION AND COLLOID CHEMISTRY (in German), H. Bechhold, Zts. f. Chem. u. Ind. d. Kol., 5:22 (1909). Considered disinfection from standpoint of colloidal chemistry, with special emphasis on adsorption by large bacterial surfaces. Aqueous solution disinfectant is better than one of different liquid. Adsorption curves show that at lowest concentrations disinfecting substance is almost completely adsorbed, while at higher concentrations adsorption follows Henry's law. Bacterial growth and death follow adsorption. Disinfection need not be caused by chemical action, since microorganisms withdrawn from disinfecting solution, can be made viable and reproductive by freeing them fully from disinfectant in indifferent solvent. Chemical combination for poisoning occurs after adsorption by organism surface.

22. ON THE PHYSIOLOGICAL EFFECT OF COLLOIDAL METALS (in German), Carlo Foà and Alberto Aggazzotti, Biochem. Zts., 19:1 (1909). Reviewed work of previous investigators. Investigations by Foà and Aggazzotti covered therapeutic preparations of colloidal metal in animals. Found that small doses of some metals hasten metabolic processes of organism, while large doses retard. Investigated catalytic action of some inorganic metal colloids alone, and in presence of oxidases. Maintained that intense catalytic action of colloidal metal caused by finely divided state of metal. Observed catalysis by various metals acting on H_2O_2 .

Found that none of colloids of calomel, Bi, or ferric hydroxide killed any test bacteria. Hyrgol (Hg) killed *B. typhi.*, and diploco. in 7 hours; *Strept. pyocy.*, *B. dysent.*, *B. diphth.*, and pneumoco. in 24 hours. Colloid Pt and of Au in 0.0125 percent solution killed *B. typhi.* and diploco. in 24 hours. Collargol (Ag) in 0.5 percent killed all bacteria in 12 hours. Colloidal olive-green Ag in 0.007 percent solution killed all above bacteria in 12 hours.

23. THE STIMULATING ACTION ON BACTERIAL MULTIPLICATION BY MINIMAL QUANTITIES OF BACTERIAL TOXINS (in German), O. Hüne, Ztbl. f. Bakt., 48:135 (1909). (Abstract is cited from V. Horelli.) Investigations showed HgCl_2 at 3.3 to 1 ppm effective to *Vib. cholera*, *B. typhi.*, and *B. coli*. Also investigated CuSO_4 and organic disinfectants.

24. ADSORPTION AND COLLOID PRECIPITATION (in German), Hugo Morawitz, Kol. Chem. Beih., 1:301 (1910). Reviewed work of previous investigators. Referred to Freundlich's theories of adsorption. Working with bone charcoal adsorbing salts of heavy metals, found first rapid adsorption followed by gradual decrease of concentration in substrate. Heavy metal salts more difficult to adsorb than materials of previous investigations. Demonstrated that for small quantities of adsorbent concentration function, x/m is no longer parabolic, but increases linearly with m . Concluded that for given volume of given solution there exists amount of adsorbent for more than which adsorption corresponds with normal parabolic concentration function, but for less than which adsorption departs from normal function; smaller concentrations of adsorbate require smaller amounts of adsorbent. Showed test data for adsorption of various salts of Ag, Pb, Zn, Cu, and Hg. Adsorbability varies over wide range. For equal value of " c ," HgCl_2 was adsorbed 30 times amount of ZnCl_2 . Anions influenced adsorption. Supposed disinfection by HgCl_2 to be closely related to adsorption and dependent on amount of bacterial surface and concentration of disinfectant. Adsorption is first stage in disinfection. Adsorbate must then diffuse into cell at rate proportional to concentration of adsorbate on cell surface. He stated that strongly adsorbable salts also act as strong precipitants of colloids.

25. GERMICIDAL ACTION OF METALS (in English), Allen C. Rankin, Proc. Royal Soc. London, 32:78 (1910). Previously Ledham and Green had ascribed inhibition of bacterial growth to oxidation of metal. Barnes and Shearer attempted to show bactericidal action of metals in water caused by formation of H_2O_2 . But Rankin maintained that bactericide was demonstrated by Zn in water without production of H_2O_2 . After boiling off O_2 from water found no

action of Al, Zn, or Cu on bacterial growth. Produced some reduction in *B. coli* by contacting with large surface Zn in water for 1 hour, but none for Al and Cu. Observed that H_2O_2 is produced by Zn and Al in water but not in sufficient quantity to be sterilizing; yet he concluded with " . . . only the minutest traces of metal are present . . . which could hardly be responsible for effects produced, and indeed could not produce them."

26. FORMATION OF DISPERSE SYSTEMS BY IRRADIATION OF METALS WITH ULTRA-VIOLET LIGHT AND X-RAYS (in German), Th. Svedberg, Zts. f. Chem. u. Ind. d. Kol., 6:129 (1910). Reviewed previous investigation on irradiation of metals. Svedberg's work showed that surface oxides on Pb, Cu, and Ag inhibited markedly colloid production by Hg. lamps. Could easily disperse by light: Pb, Ag, Sn, and Cu, but not Au, Pt, and Al. Light rays down to 4047Å showed no dispersal action. All ultra-violet lamps effective. X-rays produced colloids from Pb, Ag, and Cu in same descending order.

27. DEATH OF BACTERIA ON IMPORTANT METALS IN CONSTRUCTION (in German), Ludwig Bitter, Zts. f. Hyg. u. Infek., 69:483 (1911). Reviewed previous work of investigators. Investigated bactericide on objects ordinarily handled in life, at 15 to 19 C, relative humidity of 57 to 60 percent. Worked with *B. typhi.*, *Vib. cholera*, and *Staph. aureus*, smeared on previously sterilized objects, then after various contact periods, wiped with cotton plug, embedded same in culture medium and tested after various incubation periods. Following metals were bactericidal in descending order of activity: Cu, brass, Ag, Au, Pt, Pb, cast iron, steel, Al, Ni, Zn, and Sn. Observed that oligo. action of Au is caused by Cu impurity therein and by oxides on Au surface. Oligo. effect of commercial Pb may also be caused by impurities. Variations in test results of investigators also may be caused by different quantities of impurities in their test metals. Found dampened Ag faster bactericide than dry. Found dirty coins as effective as very new unused coins. Believed oligo. properties of coins prevents greater epidemics spread, although most oligo. coins could still spread pathogens. Utensils of Zn, Sn, steel, and enamel ware non-bactericidal. Found linoleum good bactericide after 4 years' use, wall paint less effective in 1 year; fresh calcimine strongly bactericidal, but growth promoting after several days. Worked with terrazzo, stone, tiles glazed and unglazed, plate glass, polished marble, pasteboard, earthenware, wallpaper, and quartz. On average, bacteria died sooner on smooth surfaces than on rough. Found glass to be bactericidal to bacteria smeared thereon. Advised against use of glass as substrate for control or basis of comparison of bactericidal agents. Oligo. properties probably caused by metal content of glass. Found pure quartz more bactericidal than glass

on *B. typhi*. Found stoneware slightly oligo.

28. ACTION OF SILVER PREPARATIONS IN NaCl SOLUTIONS (in German), Oscar Gros, Munch Med. Wochs., 50:2659 (1911). (Abstract is cited from V. Horelli.) Concluded that bactericide was caused by union of the Ag ion in solution with "life-essential part" of bacterium. Dilute NaCl solutions favored finer grained Ag precipitate with inherently greater solution surfaces.

29. LIGATURE AND SUTURE MATERIAL (in English), W. S. Halsted, J. Amer. Med. Assn., 60:119 (1913). Reviewed previous literature. Investigated action of foil of Ag, Cu, and brass on fresh wounds and found Ag most effective, while others irritated skin.

30. ZINC AND ASPERGILLUS (in French), Charles Lepierre, Compt. Rend. Acad. Sci., 158:67 (1914). Refuted Coupin's contention that Zn retards growth. Found Zn dose of 0.1 to 10 ppm accelerated vegetation of Asperg.

31. OBSERVATIONS ON THE ANTI-BACTERIAL ACTION OF COINS IN NUTRIENT MEDIA (in German), Desider Natonek and Helene Reitmann, Zts. f. Hyg. u. Infek., 79:345 (1915). (Abstract is cited from V. Horelli.) Worked with metals and inoculated plates. Demonstrated varying sensitivity, and effect of nutrient media constituents on sterile zone formation. Found residual oligo. in agar 5 days after metal contact removed. Worked with *B. coli*, *B. proteus*, *Sarc. lutea*, *Micro. pyogen.*, and *B. prodig.* Found some molds insensitive to metals, and yeasts hardly disturbed. Considered solubility of metals as causes of bacteriostasis. Did not agree with explanations of oligo. by Miller, Behring, and Crédé.

32. SPONTANEOUS FORMATION OF COLLOIDS OF METALS IN CONTACT WITH A DISPERSION MEDIUM (in German), H. Nordenson, Kol. Chem. Beih., 7:91 (1915). Reviewed work of previous investigators producing colloid metal solutions by boiling metal in water. Nordenson boiled silver plates both in water and in alcohol, demonstrated presence of Ag metal colloid in both; less produced when boiled in dark than when in strong light. Also, solution produced in dark showed subsequent particle multiplication when later exposed to light. Concluded that metal colloid formed in 2 stages; first was chemical reaction in which metals form oxides or hydrates by oxidation, in either water or alcohol, second was separation of metal as colloid from chemical compounds which are very sensitive to light and reducing agents.

33. FORMATION OF COLLOIDS OF METALS BY LIGHT, X-RAYS, AND RADIUM (in German), H. Nordenson, Kol. Chem. Beih., 7:110 (1915).

Considered previous supposition that light induces reactions in dispersion medium, forming strong reactive substances (H_2O_2 in H_2O), which then react on metal. To confirm this Nordenson contacted Ag sheet with 3 percent H_2O_2 solution, then stated that partial decomposition of H_2O_2 takes place on Ag surface, and Ag goes into solution as highly light-reflecting colloid particles. With 2 silver plate electrodes, up to 2 mm apart in clean ethyl-alcohol, under 220 volts for 10 minutes found solution first turned gray. Under ultramicroscope, solution exhibited weakly colloid with large particles. After further exposure to ultraviolet light, or addition of reducing agent, solution became strongly colloidal with fine dispersed particles. Believed that first, positive pole Ag metal dissolved through action of oxidizing agent produced by electrolysis, these Ag compounds dissolved in liquid traveled to negative pole where they became reduced to colloidal Ag through action of hydrogen found there. Concluded that metals first form chemical compounds in dispersion medium. These may form in dark. Action of light or other irradiation merely hastens catalytically, formation of metal colloid. Direct physical colloid formation from metals by irradiation does not take place, only secondarily, after chemical process.

34. OLIGODYNAMIC ACTION OF COPPER (in German), K. Spiro, Munch. Med. Wochs., 62:1601 (1915). Worked with Cu and yeasts in presence of H_2O_2 , mixtures of ammonia salts, amides, amino-acids, and stearic acids. Observed that oxygen plays part in oligo. action; Cu dissolves in water through oxidation; slight solubility of Cu in ammonia appears only in presence of oxygen. Cu adsorbed on cell surface, conforming with Freundlich adsorption curves; adsorption permits further dissolution of Cu from source. Cu reacts with cell-wall constituents. Cell wall resists diffusion through it. Inside cell Cu could form Cu complex salts with amino-acids, peptones, albuminoids, and lipoids found therein. Adsorption is basis of oligodynamic action.

35. ACTION OF METAL POWDER ON BACTERIA (in German), Hans Bohtz, Zts. f. Hyg. u. Infek., 82:291 (1916). (Abstract is cited from Horelli.) Worked with metal powders in media. Observed action on *B. anthracis* by Cd, Mg, Co, Cu, Ag, Bi, Zn, and Sn; and on *Micro. pyogen.* by Zn, Cu, Ag, Co, and Ni. Believed metals formed metal albuminates, thus becoming antiseptic.

36. DISINFECTION PROPERTIES OF METALS AND THE REASONS THEREFOR (in German), Th. Messerschmidt, Zts. f. Hyg. u. Infek., 82:289 (1916). Reviewed work of previous investigators. Worked with Cu metal and salts on various bacteria, and found no difference in their relative activity. Found them active on *B. subt.*, *mycoides*, *anthracis*, *enter. Gärtner*, *typhi.*, *paraty.-B.*, *coli muc.*,

coli immobil., Micro. pyogen., Strept. lances., B. violac., pyocy., mobile Haenli; Sarc. flava, auranti., 4 various water bacteria, B. dysent. Shiga-K., Vib. cholera. Found no effect on the molds Mucor, Penicillium, and Aspergillus. Tested relative effectiveness of metals and sensitivity of organisms by comparing sterile zones in infected culture plates. Found no concordance with order of test metals in chemical periodic table. Observed action of metals in nutrient media differs from action in water; Cu carbonate forming on surface of technical Cu was easily soluble in nutrient media, but practically insoluble in clean water or agar. Technical Cu found more oligo. active than chemically pure Cu. Believed that traces of arsenic, antimony, and the like found in many technical metals give them disinfectant power, included metal probably acting as a catalyst for solution of principal metal. Concluded that bactericide by metal is accompanied by formation of metallic salts and their subsequent dissolution.

37. THE OLIGODYNAMIC ACTION OF COPPER (in German), K. Spiro, Biochem. Zts., 74:265 (1916). Investigated affinities of metal ions of salts for adsorption by bacteria. Concluded that such adsorption on cell surfaces is preliminary stage to subsequent chemical reaction of metal ion and cell substance.

38. OLIGODYNAMIC EFFECT OF DILUTE METAL SOLUTIONS ON DIASTASE (in German), A. Baumgarten and A. Luger, Wien. Klin. Wochs., 32:1222 and 1224 (1917). Investigated oligo. effects of metal on fermentation processes. Found definite inhibition of diastase or trypsin solutions, either direct or when oligo. action transferred to other media. Cu more inhibitive than Ag. Believed that oligo. inhibition caused by metal salt solution mechanism. Concluded that such diastase inhibition could provide sensitive indicator for testing oligodynamic activity of oligo. sterilizing jars, and oligo. activated water. Activation of glass regarded as surface adsorption phenomenon; possible adsorbate makes chemical combination with glass upon long contact. Found no difference in sterile zone size between that of metal salt or of clean metal.

39. EFFECT OF METALS ON BACTERIA TOXINS (in German), A. Baumgarten and A. Luger, Wien. Klin. Wochs., 30:1259 (1917). Worked with diphtheria and tetanus toxins injected in guinea-pigs and mice. Found these toxins greatly reduced in toxicity after 3 to 8 days' contact with Cu.

40. PHYCOMYCES AND THE SO-CALLED PHYSIOLOGICAL DISTANCE-ACTION (in German), Fredr. Elfving, Ofv. a. Finsk. Vets. Soc., Vol. 59, Afd. A, No. 18 (1916-17). Suspended Fe plate near margin of phycomyces growth, placed both under inverted glass jar

in dark at room temp. After several hours observed peripheral sporangia had bent toward the plate in flat arcs and sharp-corner bends while other sporangia grew upright. Found such attraction across intervening distances of 2 to 3 cm. Also observed same "Fernwirkung" for Al and Zn but not for Ag, Au, Pt, Bi, Sb, Cd, Co, Ni, Sn, Pb, and Cu. However bright Mg and Cd were active. Fe plates used in darkness several years continued active. Fe plates could be activated by bright sunlight. Sheet Pt activated by electric-spark discharge remained active only $2\frac{1}{2}$ days. Activated glass plates and Pt in ozone stream but not in O_2 ; could activate many other substances. Most of these could be deactivated by flame, by washing with water or alcohol, but not by rubbing with dry cloth. Observed activation and inactivation quite irregular for any substance. Concluded that "Fernwirkung" not due to any inherent quality of metal, to hygroscopicity, to presence of H_2O_2 , to any volatile substance, or to light. "It cannot be denied that growth modification caused by outside circumstances origin of which is still very obscure."

41. EFFECT OF METAL SALTS ON DIASTASE IN LIVE PLANT CELLS (in German), Helene Langer, Wien. Klin. Wochs., 30:1260 (1917). Demonstrated that highly diluted $AgNO_3$ and $CuSO_4$ solutions acted on diastase in living plant cells.

42. INVESTIGATIONS ON PHYSICAL CONDITIONS OF COLLOIDS AND ON SILVER-SALTS-PROTEINS (in German), Wolfgang Pauli and Johann Matula, Biochem. Zts., 80:187 (1917). Made electropotential measurements of Ag ions left in $AgNO_3$ solutions for determining extent of binding of Ag to albumin. With glutin observed that this did not increase in same proportion as increase of glutin with constant $AgNO_3$ concentrations; with greater deviations for smaller $AgNO_3$ concentrations. Ag salts did not precipitate glutin, or change its viscosity. Addition of 0.04N- $AgNO_3$ solution to albumin free of globulin produced slight turbidity rapidly increasing with increasing $AgNO_3$ until heavy white albumin precipitated leaving clear substrate. Demonstrated Ag binding to albumin same as with glutin. Found casein to bind Ag in greater amounts than glutin at lower $AgNO_3$ concentrations. Observed that Ag salt-glutin complex went into reverse reaction in presence of neutral salts of alkali metals, or with alkaline-earth metals, with decreased binding of Ag to glutin in presence of these salts. Concluded that neutral salt-albumin combinations of alkali metal or alkaline-earth metal with Ag salt have their anions and cations absorbed by protein in equivalent quantities. Various proteins absorb Ag salts in different amounts.

43. FUCHSIN AS INDICATOR OF OLIGODYNAMIC ACTION OF COPPER (in German), Hermann Pfeiffer and H. Kadletz, Wien. Klin. Wochs.,

30:997 (1917). Developed agent for indicating presence of Cu in "oligodynamic" quantities: Brahms fuchsin stain with Na_2SO_3 for its reduction, mixed with agar for plating (FA) or in distilled water (FL) for test tube work. A Cu wire placed in such agar plate at 37 C soon produced dark red zone around it, sharply delineated, surrounded by zone of lighter color diminishing gradually to pink of original FA. Could indicate by FL presence of Cu in water in which Cu rod 5 cm long x 1 mm diam. was immersed for 48 hours at 37 C. Also indicated presence of Cu in glass of water container after repeated rinsing with water. Found indications for Cu by fuchsin and bacteriological tests to be parallel but could not decide whether both fuchsin reaction and bactericide were same thing. Investigated effects of temperature and conditions of metal on fuchsin indication. Indicator could show presence of oligo. Cu in water, NaCl solutions, rubber, and animal membranes, but not in air or paraffin. Investigated oligodynamic activity of paired metals as previously investigated by Thiele and Wolf. Found Pt active only when one end was wound with Cu wire immersed in plate. Cu wire at 37 C exposed to photographic plate in dark showed outline of wire on plate after 2 days, and broad elliptical zone after 7 days.

44. OLIGODYNAMIC ACTION OF DILUTE Cu SALT SOLUTIONS (in German), Hermann Pfeiffer and H. Kadletz, Wien. Klin. Wochs., 30:1221 (1917). Found reduced fuchsin indicator to react definitely to Cu salts at 10^{-12} dilution, and sensitive at 10^{-15} dilution. Ag salts indicated at 10^{-7} dilution. Used paraffin-lined glass vessels to protect tests from oligo. pollutions.

45. BACTERICIDAL ACTION OF METALS AT A DISTANCE (in German), Paul Saxl, Wien. Klin. Wochs., 30:714 (1917). Reviewed work of previous investigators. Demonstrated that 200,000/cc of B. paraty. - A, Strept., or Staph. in well water could be killed by Ag or Cu plates immersed therein 18 hours at room temperature. Obtained similar results in distilled water, tap water, and physiological NaCl solution after 48 hours' contact with Ag or Cu. Also confirmed oligo. activation of glass walls, of gelatin, and of agar and of physiol. NaCl solution; formation of sterile zones with margins conforming to contours of sterilizing medium; and variation of size of sterile zone with temperature and time of incubation, and with contact time. Observed Ag and Cu to be most oligo.; Ni very little, while other metals oligo. only in combination with Ag or Cu. Determined that oligo. bactericide was dependent on amount of metal surface although not in geometrical proportion. Observed that wrapping metal in filter paper or parchment paper did not hinder oligo. action, but did hinder that of Ag organic and inorganic compounds. Believed this to be evidence against theory that oligo. action is caused by dissolution

of metal. Confirmed the oligo. booster effect of various metal combinations: Cu in agar helped by Ag, Au, Pt in descending order, inhibited by none and indifferent to Al, Xn, and Fe; Ag in agar helped by Au greatly, Pt weakly, hindered greatly by Cu, slightly by Ni, indifferent to Al and Fe; Ni in agar helped by Ag weakly, indifferent to Cu and Fe; found these no support of metal solution theory, or any support for electropotential theory as cause of oligo. action. Concluded that oligo. action was caused by physical energy manifesting itself on surface of metal, which energy can transfer to other media and therefore can be separated from parent metal. Termed such action at distance as "Fernwirkung", which may be translated by "telergy."

46. APPLICATION OF TELERGIC BACTERICIDE OF SILVER TO DRINKING WATER STERILIZATION (in German), Paul Saxl, Wien. Klin. Wochs., 30:965 (1917). Investigated sterilization by Ag activated glass flasks. One of 700 cc activated by Ag wire immersed in water therein 12 days; flask then emptied, rinsed repeatedly with water, steam sterilized, filled with sterile water, infected with *B. coli*; after 8 hours showed 230 coli colonies as against 1000/cc in control. Same flask then rinsed, steam sterilized, filled with sterile water, infected with *B. paraty.-B.*; after 8 hours showed 1 colony as against 1700/cc in control. Same flask then repeated with *B. typhi.* gave 0/cc as against 900/cc in control. Same flask then repeated with Shiga-Kruse gave 0/cc as against 1200/cc in control. Same flask then repeated with *Vib. cholera* gave 1/cc as against 1500/cc in control. Found effectiveness greater on pathogens than bacteria native to air or water. Found no difference in color of glass, or size. Used same piece of Ag wire for 6 months' activation without noticeable diminution in its weight.

47. BACTERICIDAL TELERGY OF METALS AND METAL SALTS (in German), Paul Saxl, Med. Klin., 13:764 (1917). Further investigations of sterilization by activated glass. Test tube activated by 10 days' contact with 1 gram HgCl in 200 cc water; rinsed, steam sterilized, and used for following series of sterilization tests: - *B. paraty.* at 1500/cc reduced to 0 in 8 hours, Shiga-Kruse at 2500/cc reduced to 0 in 5 hours, *B. typhi.* at 6200/cc reduced to 2000 in 6 hours, *B. typhi.* at 1500/cc reduced to 500 in 8 hours, *B. coli* at 4400/cc reduced to 1500 in 8 hours, Shiga-Kruse at 1500/cc reduced to 500 in 5 hours, and *B. typhi.* at 1500/cc reduced to 1000 in 6 hours.

Found analogous results for AgNO₃ and for HgCl₂. Thin filter paper disks treated with solutions of AgNO₃ or HgCl₂ and dried, showed same kind of conformal sterile zones on inoculated agar plates as produced by metal pieces. AgNO₃, HgCl, HgCl₂ placed in

rubber sacs tied up tightly and buried in inoculated agar produced conformal sterile zones. Ag or Cu metals in rubber sacs did not produce sterile zones. HgCl_2 in rubber sac tied up with silk thread, only long end of thread embedded in inoculated agar, thread produced sterile zone; same effect produced by Pt wire tied to rubber sac with AgNO_3 ; Pt by itself is non-oligo. The foregoing indicated that AgNO_3 , HgCl , and HgCl_2 have antiseptic properties. "This unknown physical force can be conducted (by Pt wire, silk thread), permeated (through rubber membrane, as well as into glass), and can activate other bodies."

48. PREPARATION OF VACCINES BY BACTERICIDE OF OLIGODYNAMIC ACTION (in German), Paul Saxl, Méd. Klin., 13:1209 (1917). Proposed simple method of preparing sterile vaccines; oligo. action of metals killed bacteria but did not affect the agglutinin. Again investigated combinations of metals. Found Ag or Cu alone active. Cu wound around Ag, or both wires placed near each other in plate made Cu active and Ag inactive. Au alone found inactive. Pt alone weakly so, but either made active by combining with Ag. Found oligo. of metals to act through vegetable or animal membranes, and through cork. Found CuSO_4 weakest and HgCl_2 strongest oligo. of metal salts, and all stronger than Ag or Cu metal. Metal Hg found inactive. Maintained that almost equal activity of insoluble HgCl as of slightly soluble HgCl_2 was argument against solution theory of oligo. action. Found activation of glass varied directly with amount of surface of activating agent. Could deactivate glass by prolonged heating at over 60 C. or by wiping with dry cloth.

49. ON THE THEORY OF THE SO-CALLED OLIGODYNAMIC PHENOMENON (in German), A. Baumgarten and A. Luger, Wien. Klin. Wochs., 31:118 (1918). Baumgarten's and Luger's investigation of oligo. action through rubber sac confirmed Saxl's observations. However, working with AgNO_3 , HgCl , or HgCl_2 in heavy walled (1 mm) rubber tubing sealed at both ends by glass rods and paraffin, produced no sterile zones when embedded in inoculated agar plates. Differing from Saxl, they maintained that action of HgCl does not provide argument against solution theory of oligo. HgCl could decompose under ordinary laboratory conditions of light, humidity, temperature, alkali from glass or nutrient medium, then can dissolve and become active. HgCl_2 could exert corrosive action on rubber, making it permeable to Hg salt solutions. Maintained that filter paper or parchment paper are no barriers for solutions of salts of Ag, Hg, or Cu. Saxl's observation of dependence of oligo. on surface of agent lends equal support to solution and adsorption theories of oligo. action. Observed that water boiled with Ag produced much greater oligo. activation than when Ag-activated in refrigerator. They inferred chemical nature of oligo. as result of their work.

50. ADSORPTIVE DISINFECTION BY METAL COMBINATIONS AND DISPERSE GALVANIC COUPLES (in German), Heinrich Bechhold, *Zts. f. Elektrochem.*, 24:147 (1918). Found parallel between adsorbability for dyes and for bacteria. Agreed with Eisenberg that difference in staining ability between gram-positive and negative bacteria caused by difference in bacterial surface of each group. However, Bechhold's comparison of adsorption of gram-positive Staph. with that of gram-negative B. coli showed no discernible difference. Believed that disinfection with metals caused by their ions. He covered boluses and charcoal with thin metal coats; was then able to adsorb and kill bacteria at same time. Found Ag, Hg, and Cu, strongly bactericidal. Found enhanced bactericide by mixing the various metal covered boluses together "thereby obtaining millions of galvanic circuits designated as 'disperse galvanic couples'." Found Cu boluses with Au boluses much weaker than those of Cu with Ag or Cu with Hg. However, he found mixtures of colloidal metals non-galvanic. Observed unequal sensitivity of various bacteria to galvanic couples.

51. BACTERICIDAL ACTION OF METALS AND METAL SALTS (in German), H. Schlossberger, *Med. Klin.*, 14:204 (1918). Was unable to verify Saxl's work with oligo. effect through rubber. Schlossberger could neither duplicate Saxl's bactericide of water activated by 14 days' contact with Ag wire, nor from flasks activated by 4 weeks' contact with various metal salts. He worked with Cu, Ag, and Ni; with B. typhi. paraty.-B., coli., Micro. pyogen., dysent. Shiga-Kruse and Flex., and Vib. cholera. Did agree that Cu, and to less extent Ag, are oligo. bactericidal. Concluded that oligo. action does not depend on radiation or catalysis, but on solution of small quantities of metal which become absorbed by surfaces of bacteria.

52. RELATION OF GRAM-POSITIVE AND NEGATIVE BACTERIA TO OLIGODYNAMIC ACTION (in German), Oskar Bail, *Wien. Klin. Wochs.*, 32:751 (1919). Investigated bactericidal effect of water activated by Hg, Ag, Pb, Fe, and Au on B. anthracis, subt., coli, typhi., proteus, prodig., pyocy., Coryn. pseudodiph., Sarc. alba, flava, Micro. pyogen., Staph. aureus, and Vib. cholera. Observed gram-positive to be sensitive, gram-negative resistant, but exceptions thus: gram-negative Vib. cholera were very sensitive while gram-positive Sarc. and some Micro. were highly resistant. Observed no action on spores. Found water activated by Ag less oligo. than by Hg while Pb, Fe, and Au, were inactive. Addition of dead bacteria decreased oligo. action of water.

53. SOLUBILITY OF HIGHLY INSOLUBLE SILVER COMPOUNDS DEMONSTRATED BY THEIR BACTERICIDE (in German), H. Bechhold, *Kol. Zts.*, 25:158 (1919). Believed that solubility of Ag salts could be

indicated by their bactericidal actions. Determined relative oligo. bactericide of various Ag salts by measuring sterile zones they produced in agar plates inoculated with Staph. Found AgI at 10^{-8} dilution, AgBr at 0.14×10^{-7} , and AgCl at 10^{-5} , to be bactericidal. Ag₂S was soluble down to 10^{-17} dilution but was not bactericidal. Compared sensitivity of various bacteria to oligo. action of Ag and AgCl by measuring sterile zones in agar plates. Found size of sterile zones to vary with agar-bed thickness, diffusion constant, temperature, and solubility of agent. Oligo. action need not be postulated upon some mysterious force but acts according to well known physico-chemical laws.

54. ON THE ACTION OF SALTS AND IONS ON BACTERIA (in German), Philipp Eisenberg, *Ztbl. f. Bakt.*, 82:69-207 (1919). Made exhaustive investigations of effects on bacteria of many anions and cations of various salts. Found relative toxicity for following anions in descending order: With Na -- ClO₄, SCN, Form, Ox, Citr, NO₃, Br, ClO₃, Cl, SO₄; with Cd -- Br, I, ClO₃, NO₃, Cl, SO₄; with Zn -- I, Br, ClO₃, Cl, NO₃, SO₄; relative toxicity for following cations in descending order: with Cl -- Hg, Pt, Au, Co, Cd, Pb, Ni, Cu, Al, Zn, Fe, Cr, Fe, etc.; with NO₃ -- Ag, Cd, Co, Ni, Be, Pb, Ba, etc.; with SO₄ -- Co, Cu, Cd, Zn, Al, Be, Fe, etc. Found much variation of sensitivity of various bacteria to any given salt and of toxicity of various salts to any given bacteria; no conformance of bactericide with gram specificity or of genus, group, or strain of bacteria. Believed toxicity of salts to be additive function of colloid - chemical activity of component ions; purely molecular action (plasmolysis) must also be considered. Of fundamental importance are kind and amount of electric charge on ions, and ease with which charges can be transferred. Killing and growth inhibition are both manifestations of same poisoning action. Poison can disturb organism through catalytic destruction of bacterial protoplasm by making substrate unsuitable for metabolism by substitution or addition of substances; produce death by disturbing chemical-colloid structure of bacteria in many ways, or, can interfere with normal respiration processes by changing permeability of cell membrane.

55. BIOCHEMICAL STUDIES ON ASPERGILLUS NIGER (in German), Hanna Lappalainen, *Ofv. a. Finsk. Vets. Soc.*, Vol. 62, Afd A, No. 1 (1919). Lappalainen investigated physiological processes of fungi in cultures. She observed growth to be so irregular as to preclude confining results to any one particular process. Cause thought to have resulted from small quantities of substances originating in vessels of cultures. Investigated growth values of fungi in cultures to determine various effects on vessels. In 90 flasks of Jena "N," Jena "16," and Reymeyer glass found no regularity in growth; dry weights of culture after 4 days ranged

from 0.19 to 0.92 g; after 12 days acidity ranged from 3 to 60 cc; all cultures were made from same emulsion and same inoculation. Growths in Reymeyer glass showed more regularity. Cultures obtained in vessels of platinum, quartz, or Jena "16" glass could be made to be similar to those obtained in Jena "N" glass by: (1) using nutrient media therein previously sterilized in Jena "N" glass; (2) adding pulverized Jena "N" glass to medium; or (3) adding ZnSO_4 to nutrient media. Concluded therefrom that Jena "N" glass contained Zn. Observed relation of culture growths to previous use of vessels. Could not deactivate vessels by treating with (1) 2% HNO_3 ; (2) 0.035 percent, 7.0 percent, or 12 percent HCl ; (3) 3 to 5 percent citric acid solution; (4) nutrient media, or solutions of their constituent salts; (5) nutrient media plus 3 percent citric acid, or with 3 percent K_2CO_3 , or with Na_2CO_3 cold or at 35 C. Obtained some deactivation with Na_2CO_3 at 65 C, by boiling vessels in water over open flame or $1\frac{1}{2}$ hour in sterilizer, and with NaOH solution. Concluded that chemical composition of vessels have important effect on life processes of fungi. Zn in glass may be transferred to nutrient media or to fungi.

56. ON THE OLIGODYNAMIC ACTION OF METALS ON BACTERIA AND HIGHER PLANTS (in German), R. Köhler, Ztbl. f. Physiol., 34:145 (1919). (Abstract is cited from V. Horelli.) Worked with Cu and Zn on *B. coli*, typhi. and some Coccaceae. Concluded that oligo. action depended on solubility of metal. Dissolution of metal occurs spontaneously without intermediate action of bacterial metabolic waste products.

57. STERILE ZONES AND FORMS OF THEIR MARGINS (in German), L. Löhner, Wien. Klin. Wochs., 32:911 (1919). Found following zones in succession about metals placed in inoculated agar culture plates: sterile, bactericidal, growth inhibiting, growth promoting, and indifferent. Found size of zones and their makeup to vary with solubility and diffusibility of metal in nutrient medium, its bactericidal power, ambient temperature, length of contact time, mass and amount of surface of metal, nutrient composition, speed of solidification of medium age, and kind of bacteria present, light, etc. Found chemically pure Ag to be non-oligo. Certain metal doses hindered growth rather than killed bacteria. With certain doses of metal bacterial growth was faster than rate of dissolution and diffusion of metal in medium, resulting in formation of swollen margin of profuse growth (Randwulst) about sterile zone.

58. OLIGODYNAMIC ACTION OF METAL (in German), Gottlieb Salus, Wien. Klin. Wochs., 32:1220 (1919). Placed paramercia in Ag-activated water with H_2SO_4 . After some time organisms exhibited

brown spots. Salus identified these as H_2S inside dead cells, thus demonstrating Ag in solution in activated water. Believed Ag most oligo. of metals; Au and Pt inactive. Was able to activate tap water by 8 days' contact with Ag coins, wire, or leaf, and with Cu wire. Such water was highly bactericidal. Light has no effect on oligo. Believed that oligo. action is purely chemical dissociation or ionization.

59. NEW OBSERVATIONS ON ACTION OF OLIGODYNAMIC SUBSTANCES (in German), Paul Saxl, Wien. Klin. Wochs., 32:975 (1919). Succeeded in activating bottoms of petri dishes inverted over Ag grains, powder and wire coil, separated from dish bottom by air, exposed thus for 6 weeks. Bottoms then covered with 3 cc of B. coli emulsion in 1.5 percent NaCl solution kept 24 hours, at room temperature; showed counts of 625, 0, and 510/cc as against 1244/cc for control. Placed $HgCl_2$ pills in bottom of petri dish, supported piece of filter paper 1 to 2 cm above this, placed glass splinters on filter paper, covered dish, and kept thus 14 days. Splinters then showed oligo. activity by producing sterile zones in inoculated culture plates. Chemical tests gave no indication of $HgCl_2$ on glass splinters. Activated splinters in bacteria emulsion with 1 percent NaCl showed no inhibited bactericide. Concluded therefore that there was no volatilization of Ag or $HgCl_2$ to activate glass through air. Contacted 50 cc of 4 percent NaCl solution with 100 g activated glass. Solution became active enough in 1/40 dilution to kill B. coli of infinite concentration in 1 hr. Activated quartz sand and boluses could not thus transfer activity to NaCl solution. Inoculated agar dish inverted over lid on which was placed watch glass containing $HgCl_2$ tablet. Distance between agar surface and tablet was 3 cm. After 3 hours' exposure found sterile zone in agar surface as an image of tablet beneath. Substances activated by $HgCl_2$ could not be deactivated by distilled water. Developed method of indicating presence of oligo. activity in activated NaCl solutions by means of $KMnO_4$. Observed by such indicator that substances activated through air gave much stronger oligo. reactions than those activated through contact with $HgCl_2$ solution. Assumed, therefore, that although reasons for bactericide are same in both cases, still mechanisms must differ; a chemical process is involved in contact activation, but could not define that for activation through air. Emphasized fact that transferred oligo. activity worked better in bacterial suspensions in NaCl solutions than on bacterial emulsions in water. The stronger the NaCl solution, the better the results. Reverse was true with activation by contact with $HgCl_2$; a 1 percent NaCl solution definitely hindered action.

60. ON THE OLIGODYNAMIC ACTION OF COPPER ON BACTERIA (in German), Arnulf Streck, Hyg. Rund., 29:685 (1919). Streck

concerned with application of oligodynamic sterilization to drinking water practice. Worked with Cu on *B. typhi. murium*, coli, septicem-hemorrh. and *B. pyocy.* Used city tap water in vessels of ordinary glass washed with HCl, rinsed in tap water, and dried in sterilizer. Water was activated by Cu leaf suspended therein. Bactericide was evaluated by counts in agar plates after 24 hours' incubation at 37 C, and again 24 hours later. Observed the following: (1) for given amount of Cu surface, contact time for sterilization varied directly with volume of water in which metal was immersed; (2) bactericide occurred sooner with increasing Cu surface for given volume of water; (3) Cu was strongly bactericidal on *B. paraty.* and coli groups, and inhibited growth of *B. pyocy.* and septicem.

61. ON THE OLIGODYNAMIC ACTION OF METALS (in German), D. Acél, Biochem. Zts., 112:23 (1920). Water activated by Ag contact was evaporated in white porcelain dish. Few drops of $(\text{NH}_4)_2\text{S}$ in dilute solution added to residue exhibited brown-black deposit in dish (Ag_2S). Concluded activity caused by dissolution of Ag in water. Demonstrated that bactericide increased with amount of metal surfaces. Metal was effective in distilled water and in tap water, in light, and in darkness.

62. ON THE OLIGODYNAMIC ACTION OF METALS (in French), Casimiro Affonso, Compt. Rend. Soc. Biol., 83:1179 (1920). Performed tests to verify oligo. action. Observed formation of sterile and other zones in agar plates by metal. Pure Ag gave no sterile zone but alloy of Ag plus Cu gave large sterile zone. Concluded that impure metal more oligo. than pure. Found sensitivity to vary with kind of bacteria. Observed oligo. action effected medium by changing its color or formation of crystals therein. Observed that results in agar differed from those in gelatin. Believed oligo. bactericide to vary with medium makeup.

63. COLLOID STUDIES ON STRUCTURE OF RED BLOOD CORPUSCLES AND ON HEMOLYSIS (in German), H. Bechhold and W. Kraus, Biochem. Zts., 109:226 (1920). On basis of Ehrlich's observations that HgCl_2 in high concentrations hardens red blood cells, while in low concentrations produces hemolysis, Bechhold and Kraus proposed investigation of structure of erythrocytes. Hardening is caused by action of ions, lysis caused by action of molecules. HgCl_2 found to be soluble in surface of blood disc. From there it can penetrate to cell interior where it can react with albuminoids, producing coagulation or hemolysis. Latter occurs with contraction of inner membrane, forcing out of fluid content, and dissolution of hemoglobin.

64. ON THE OLIGODYNAMY OF SILVER (in German), R. Doerr,

Biochem. Zts., 106:110 (1920). Investigated oligo. bactericidal action of Ag and Ag salts on *B. typhi.*, on water bacteria that were vegetative, gram-negative, non-proteolytic (his group "A"), and proteolytic (his group "B"). Ag wire embedded in gelatin plate inoculated with each of above groups on different sectors showed after 48 hours complete disappearance of group "B", increased growth of group "A", and slow decrease of *B. janthin* with its complete disappearance after 6 days. Further tests demonstrated that NaCl solutions did not completely inhibit bactericidal power of oligo. activated water. Observed water bacteria slightly less sensitive to activated water than *B. typhi.* Latter were killed by AgNO_3 at $1/5 \times 10^{-6}$ dilution in 30 minutes. Spores were not killed by concentrated Ag_2O solution in 12 hours. Observed no real specificity of metals to bacteria. Could find no difference in required contact time of Ag metal or Ag salts solutions. Distillate from activated water proved to be non-bactericidal, but residual original liquor showed increased bactericide. Serum in activated water hindered oligo. action; believed that albumins adsorbed Ag ions. Maintained that distilled water could become bactericidal from contact with metal in still-condensor apparatus, metal containers, etc. Recommended double distillation of water in glass.

65. ON THE OLIGODYNAMY OF SILVER (in German), R. Doerr, Biochem. Zts., 107:207 (1920). Doerr concerned with demonstrating validity of his assumptions that oligo. action is chemical and that bactericide by metals depends upon metal compounds on metal surface and their dissolution in contact with water. Repeated use of same Ag metal strip in agar plates infected with *B. typhi.* showed progressively decreasing size of sterile zones until none was produced. Ag strips heated in Bunsen flame, or boiled repeatedly in water produced no sterile zones, thereby indicating deactivation of metal. However, first batch of such boiled water was highly bactericidal while succeeding batches showed decreasing activity. Investigated methods of activating metals previously deactivated by flame, by boiling in distilled water, or by long contact with agar. Pt was not activated by 0.3 percent HCl, or 1 percent NaOH. Ag was not activated by NaOH but was by HCl. Powdered Ag_2O fixed on filter paper disc embedded in agar dish infected with *B. typhi.* showed larger sterile zones than with Ag metal. Zones produced by AgNO_3 treated paper discs were of same size as from Ag metal. Ag_2O fixed on filter paper placed in fish bladder with 3 cc distilled water, bladder closed and embedded in infected agar plate, produced sterile zone conforming to shape of bladder, not of filter paper. Assumed that Ag_2O dissolved in water in bladder, dialyzed through it and through agar equal distances in all directions. Figures out from Ag sheet placed in bladders with distilled water produced sterile zones in

which contours conformed to shape of Ag pieces, not of sacs. Observed formation of profuse bacterial growth in form of ring around sterile zones produced by Ag metal, Ag_2O and AgNO_3 . Assumed that profuse growth was caused by nutrient quality of weaker concentrations of Ag. Demonstrated this by agar-slant tubes inoculated by *B. typhi*. and with various concentrations of Ag-activated water. With high concentration observed sterility. Decreasing concentration produced increased growth, then sterility, then gradually increasing growth. Demonstrated hemolysis by Ag metal, and its inhibition after heating or boiling metal. Concluded that Saxl's telergic theory of oligo. was not substantiated; that oligo. bactericide of Ag depends upon formation of difficultly soluble Ag compounds upon its surface by contact with atmospheric O_2 or H ions, and upon their subsequent dissolution in water Ag ions become cytotoxic. Heating changes compound on the Ag metal, thereby inactivating it.

66. OLIGODYNAMIC METAL ACTION IN NATURE (in German), R. Emslander, Kol. Zts., 27:254 (1920). Observed sterile zones in moss growths on slate roof around bare Cu electric wires.

67. ON THE SUBJECT OF OLIGODYNAMIC HEMOLYSIS (in German), W. Hausmann and W. Kerl, Biochem. Zts., 112:122 (1920). Hausmann and Kerl worked with human erythrocytes in agar plates and with metal plates embedded therein. They observed hemolytic activity in following descending order: Ag, Cd, Cu, Mg, Ni, Pb, Sn, and Zn. Activities of Ag, Cu, and Mg were especially rapid.

68. ON HEMOLYSIS BY OLIGODYNAMIC METAL ACTION (in German), Leo Hess and R. Reitler, Med. Klin., 16:982 (1920). In 5 percent erythrocyte suspension Hess and Reitler found Cu, Cd, and Pb hemolytic, but none by Ag, Sn, Al, Sb, Mo, and Ni. In 1 percent suspension they observed hemolysis in following descending order: Cu, Cd, Pb, Ag, Ni, Mo, Sb, and Al. Made NaCl solution hemolytic by contact with Cu. Hemolysis in serum was promoted by lengthy contact with Cu. Cu activation could be increased by quartz lamp light, increasing Cu surface, or by longer contact time.

69. DISINFECTION BY METALS, AND METAL SALTS; THEIR STERILE ZONES IN AGAR PLATES (in German), Alfred Luger, Wien. Klin. Wochs., 33:833 (1920). Developed technique of evaluating bactericide by analysis of the sterile zones produced by disinfectant in infected media plates. Duplication of Saxl's work disproved telergy theory of oligo. Such action occurred because of volatilization. Believed oligo. action caused by chemical solution.

70. INFLUENCE OF COLLOIDAL METAL SOLUTIONS ON LOWER ORGANISMS AND ITS CAUSES (in German), Olga von Ploetho, Biochem. Zts., 110:1

(1920). She noted work done by previous investigators on action of colloidal Au on lower organisms, but none available for colloidal Ag or Cu. Investigated action of colloidal Au and Ag on *B. megatherium*, various *Thiobacteriales*, *Chlamidobacteriales*, *Beggiatoa min.*, *B. brassicae*, various algae, and molds. Demonstrated definite growth inhibition and killing power of colloidal Ag and Cu on molds, but not for col. Au. In protected Au or Ag sols there was no absorption of metal, but some molds absorbed metal from weakly alkaline, unprotected Au sols. Some molds absorbed no Au under any concentrations. Au absorption had no damaging influence on the tested molds. Found sensitivity varying with organism; *Asperg. niger* most sensitive, *B. brassicae* less, *B. megath.* least. Absorption and adsorption of col. metal was found to be conditioned by quality of electric charges on organism surface, in substrate, and on colloid particles. Absorption of metal produced no change in cell wall contour. There was no evidence of penetration into interior plasma. Cell wall was thoroughly impregnated with Au particles. Au was not retained as any chemical compound of wall components, but only in its colloidal elemental state.

71. ACTION OF METAL ON GROWTH OF BACTERIA (in German), Walter Seiffert, *Munch. Med. Wochs.*, 67:1437 (1920). Seiffert investigated various zones produced by Ag in endoagar plates infected with various bacteria. *B. coli* often produced profuse growth margin around sterile zone. *B. typhi.* produced sequences of zones. *B. paraty.* gave profuse growth margin on endoagar but not on agar. *Micro. pyogen* gave sequence of zones on agar. *Vib. cholera* produced only one sterile zone. Concluded that growth promotion, inhibition, or bactericide was conditioned by physical and chemical characteristics of culture media, state of metal, resistivity of bacteria, ambient temperature, etc.

72. INVESTIGATION OF OLIGODYNAMIC TELERGY (in German), Wilhelm Spät, *Wien. Klin. Wochs.*, 33:509 (1920). With reference to Saxl's "Fernwirkung", Spät asked: "If the phenomenon is caused by vapor, how is it possible to produce a sterile zone of such exact image and contour of the sublimate tablet, with such sharpness of boundary? A radiation phenomenon must be assumed." Proceeded to perform experiments tending to confirm Saxl but finally concluded that effect was caused by vapor on the basis of following: Agar plate activated by sublimate at distance before inoculation proved bactericidal upon subsequent inoculation. Held that such could be caused not by radiation, but only by sublimate vapor stored in agar. Petri dish inverted above HgCl_2 solution. Dish bottom became opalescent, and proved bactericidal. Also found that opalescence could be wiped off with gauze swab, with no subsequent bactericide on inoculated agar spread on plate

bottom. Claimed mere wiping could not remove activity from glass if it was caused by radiation.

73. THE OLIGODYNAMIC TELERGY OF SUBLIMATE (in German), Oskar Weltman, Wien. Klin. Wochs., 33:1068 (1920). Repeated Saxl's experiments with powdered glass on filter paper supported over HgCl_2 pastiles. Found traces of Hg therein by chemical indicator, and took this as proof of volatilization of the agent, rather than action of some mysterious physical force, "Fernwirkung." Same tests demonstrated no telergy for Cu metal, CuSO_4 , Ag, AgNO_3 , or metallic Hg. Criticized Saxl's use of KMnO_4 as indicator of oligo. activation. Maintained that color reaction could be produced also by organic matter absorbed from surrounding air, from alkalis from the glass, or by organic matter absorbed from cork or other organic stoppers. Concluded that formation of HgO was mechanism of oligo. in this case.

74. INVESTIGATIONS ON DISINFECTION OF SOME NEW SILVER PREPARATIONS (in German), H. Bernhard, Ztbl. f. Bakt., 85:46 (1921). Observed that Ag has strong affinity for Cl. AgCl is formed from NaCl regularly present in body fluids and in presence of albumins. Ag Cl formed is peptized by albumins. In bacterial disinfection heavy metal salts make irreversible combinations with protoplasmic albumin of the bacterial cell, forming insoluble compounds.

75. ON THE NATURE OF THE ANTI-BACTERIAL ACTION OF METAL (in German), A. Buschke, F. Jacobsohn, and E. Klopstock, Deu. Med. Wochs., 51:595 (1921). Demonstrated that presence of O_2 was necessary for Tl to be oligo. active. Found crystals in well-aerated agar plate around sterile zone of Tl; the greater the air supply, the more the crystals. Spectroscopic examination showed this section of agar to contain Tl; assumed these crystals to be TlOH . No crystals found upon exclusion of O_2 from agar. Upon partial elimination of O_2 found sterile zones frequently, but no crystal deposits; but with further aerobic incubation the deposits always emerged in sterile zones. However, they found many aerobic incubations formed sterile zones without deposits, and deposits in plates without sterile zones. Their work with Ag, Cu, Tl, Bi, and Hg showed no oligo. action if O_2 was eliminated. They explained oligo. action thus: With O_2 from the air TlO_2 forms on Tl surface then TlOH which easily diffuses through medium and provides ions which combine with albumin and oxidase of bacteria, producing bactericide. Action must include formation of metal oxides or carbonates which must then form ionic solutions.

76. ON THE OLIGODYNAMY OF SILVER (in German), R. Doerr, Biochem. Zts., 113:58 (1921). Active Ag metal pieces were

deactivated by heating in flame. Some Ag strips immersed in liquid paraffin in jars, others placed in porcelain dishes exposed to air. After 10 and 52 days, neither gave sterile zones in infected agar plates. After 164 days air-contacted strips produced sterile zones, paraffin-immersed strips none. Demonstrated that Ag metal that had activated water with 2 months' contact imparted no activity to another batch of distilled water after 8 days' contact. Also, oligo. bactericide of previously Ag-activated water was increased by further contact with "fresh" Ag metal. Modified petri dish technique by permitting metal test objects to remain in them ample time at 15 C before incubation at 37 C, thereby permitting soluble metal compounds to diffuse farther into agar. Observed the Ag in agar gave larger sterile zones for *B. coli* than for *B. typhi*. Also observed various zones of growth and sterility. Increasing amounts of 1 percent acetic acid added to nutrient agar infected with *B. coli* produced increasingly larger sterile zones around Ag metal. Found similar effect of pH on *B. typhi*. Believed that the bacterial metabolic wastes produced oligo.-active Ag compounds, which are then absorbed in protoplasm of dying bacteria.

77. ON THE STUDY OF THE SO-CALLED OLIGODYNAMIC PHENOMENA (in German), Otto Drechsel, Ztbl. f. Bakt., 53:288 (1921). Reviewed work of previous investigators. He investigated oligo. effects of CuSO_4 , HgCl_2 , CdSO_4 , $\text{Co}(\text{NO}_3)_2$, NiSO_4 , ZnSO_4 , and NaAuCl_4 , on various *Spirogyra*. Many disturbing test factors caused irregularity of results. Made following deduction therefrom: Bactericide requires that poisoning metal go into solution and produce metal ions in medium. Bacterial cell walls adsorb metal ions which permeate through it to protoplasmal membranes. Substances therein react with metal resulting in change of membrane permeability, hastening or retarding cell respiration. Dyosmosis then begins with still further adsorption of poisoning substance, until finally death occurs. The oligo. process is gradual storing up of injurious substance and is mass-action phenomenon. If dilution is too great organism sets up immunity and exhibits growth stimulation. Observed tendency of metal adsorption on glass; pointed out its similarity to adsorption and long time retention of dyes on glass; and believed that "after" or "distant" action of Cu, Ag, Hg, on glass was analogous with that of dye.

78. THE ACTION OF POISONS ON ENZYME REACTIONS; IV. ELECTROMETRY AND THE COMBINATION OF SILVER AND COPPER WITH SACCHARASE (in German), H. von Euler and Olaf Svanberg, Fermentforschung, 4:142 (1921). Investigated effect of ions of Ag, Hg, and Cu on saccharase prepared in pure form. Observed saccharase poisoned most strongly by salts of Ag and Hg, and very little by CuSO_4 .

Actions with Ag and Hg were quantitatively reversible. Constructed typical dissociation equilibria curves relating inversion rate to concentration of poison. They indicated that most often one molecule of saccharase was completely inactivated by one Ag ion. Ag salts acted in proportion to salt concentration; Hg salts (HgCl_2) did not. Action of metals on saccharase was postulated as follows: When in low concentrations, metal ions form organic complexes with enzymes in stoichiometric conformance. Various enzyme inactivating substances are bound to various groups in enzyme molecule. "The inactivation cannot occur exclusively through the attaching of the poison to a single, particular group of the enzyme molecule. Especially, can it not be assumed that the poison is always bound to that group of the enzyme which the substrate normally calls forth Possibly, the binding of the enzyme molecule and poison does not lead necessarily to inactivation of a molecule, but to one of less activity." Found strong affinity for Ag by egg albumen, cystein, and nucleinacids but none as strong as of saccharase. The nucleinacids showed lesser affinity for ions of Cu than of Ag.

79. ON THE SO-CALLED OLIGODYNAMIC ACTION OF HEAVY METALS AND HEAVY METAL SALTS (in German), W. Falta and M. Richter-Quittner, Biochem. Zts., 115:39 (1921). Engaged in the investigation of oligo. action for 3 years. Found activity in following descending order: Cu, Hg, Ag, Pb, Sn, Zn, Al, Fe, Mg, and Pt. Test tubes activated 8 days by Ag metal in water colored 1 percent alcoholic guaiac solution green; colored 1 percent resorcin solution tan; decolorized methylin blue and indigo blue; colored weak HCl solution of malachite-green; and coagulated albumins in various solutions and sera. In Hg-activated unglazed porcelain dishes starch hydrolyzed to sugar in few days. These tests indicated that greatly diluted metals can produce various chemical reactions without coming directly into reaction. They concluded that oligo. action is brought about by dissolution of minimal amounts of metal which are adsorbed by glass, and can be washed out therefrom with great difficulty.

80. DEMONSTRATION OF OLIGODYNAMIC ACTION ON LUMINESCENT BACTERIA (in German), E. Friedberger, Berl. Klin. Wochs., 58:897 (1921). Ag metal embedded in agar plate infected with luminescent bacteria produced concentric zones of sterility, of enhanced growth and of natural growth.

81 EFFECTS OF METALS AND METAL SALTS ON BACTERIA AND BACTERIAL TOXINS (in German), K. Laubenheimer, Zts. f. Hyg. u. Infek., 92:78 (1921). Investigated Saxl's "Fernwirkung" phenomenon. Activated lid of petri dish by placing HgCl_2 thereon for 3 hours; such lids could kill staph. and fungi but not B. coli in agar

plates below the lids. Since liquid Hg could produce telergic bactericide, while Hg mixed into paraffin salve could not, Laubheimer was inclined to believe that such telergy was caused by vaporization of bactericidal agent, although his tests with AgNO_3 showed no such action. Most noteworthy was the fact that he always obtained sharply bounded sterile zones. Found that sterile zone conformed to contour of metal salt solution below and that diameter of zone decreased with increased distance above oligo. material. This led him to speculation that if action were caused by volatilization of the metal, then increase in distance should show larger sterile zone diameters instead of reverse. Found filter paper no barrier to transmittal of telergic oligo. bactericide, but paraffined paper was barrier. Mica strip with cutout in shape of cross placed slightly above oligo. material as partial screen to telergy produced a sterile zone in agar above, in image of cross cut-out, but smaller in size. Said these tests were final proof of vapor theory. Repeated Saxl's work with metals and metal salts in rubber sacs. Found by chemical indicators that even though rubber was impermeable to water it was permeable to "Hg vapors." Observed transfer of bactericidal power to glass after contact with HgCl_2 . Explained this was caused by adsorption of HgCl_2 by glass; could be removed with great difficulty by water, easily by ammonium sulfate, and by greater adsorptive powers of bacterial surfaces. Activated water by placing silver spoon therein and found it sterilizing after 6 days' contact. After removal of water and spoon, waters refilled in flask showed bactericidal effects and flask remained active several days. For heavily polluted waters, long contact times were required.

82. THE GROWTH INHIBITION BY COPPER SALTS ON PATHOGENIC BACTERIA (in German), Gräfin von Linden, Ztbl. f. Bakt., 85:136 (1921). Reviewed work of previous investigators. Gräfin von Linden's work begun in 1912 dealt with effect of Cu salts on *B. typhi.*, paraty.-B, dysent. Shiga-Kruse, *Vib. finkler*, *Vib. cholera el Tor*, and *Staph. pyogen.* and *aureus*, as well as on *B. tuberc.* in agar media. Found *B. tuberc.* sensitivity to Cu so great as to be affected by secondary oligo. effect of glassware. Least affected were air and water cocci, and *Staph. aureus*. Medium sensitivity was shown by *B. paraty.-B.* and dysent. Shiga-Kruse. High sensitivity was shown by *Vib. cholera el Tor*, and *B. typhi.*, with *Vib. finkler* less sensitive than *Vib. cholera*. In water cultures, 2 gamma/liter Cu killed about 2 mg culture mass of *Vib. cholera el Tor* in 1 hour, while 200 gamma/liter for 50 hours was necessary to kill *Vib. finkler*. CuSO_4 at 10^{-7} dilution made *B. typhi.* non-viable in 2 hours in light, but in dark 10^{-6} dilution was required. Presence of albumin decreased oligo. effect for all bacteria. Such decrease in bactericide was not

constant and not dependent upon amount of albumin in medium. Deemed concentration of salt unimportant since weaker solutions killed as well as higher concentrations. Did believe, however, that kind of salt made difference. Cu-lecithin appeared most effective when added as emulsion to medium, but not effective for all bacteria. Good for *B. typhi*, paraty. and dysent., but not for *Vib. cholera* el Tor. Cu impregnated charcoal showed better bactericide for *B. typhi* in water culture, but was less active than other Cu preparations. Her work with Cu salts in vivo proved irregular and inconclusive. Activated glass by Cu salts, measured adsorption and determined their bactericidal effects.

83. THE ANTI-BACTERIAL ACTION OF SILVER ADRENALIN COMPOUNDS (in German), Alfons Mader, Munch. Med. Wochs., 68:331 (1921). Sought means of internal therapy with Ag-carbon. Contains nothing of significance here.

84. INVESTIGATIONS ON THE OLIGODYNAMIC ACTIVATION OF WATER BY COPPER (in French), A Sordelli and R. Wernicke, Compt. Rend. Soc. Biol., 85:317 (1921). Sordelli and Wernicke investigated activation of aq. dest. by pure reduced Cu in various atmospheres. Bactericide was determined with water activated for 62 days, on *B. paraty.*-A. and -B. They observed constant parallel between bactericide and Cu solubility. They determined that water could be activated only in presence of O₂, CO₂, or acid.

85. STUDIES ON OLIGODYNAMICS (in Spanish), Raul Wernicke and Alfredo Sordelli, Anales de la Asoc. Química, 9:145 (1921). Made extensive review of previous investigations, with digest of their findings. Performed confirmatory tests for micro-determination of Cu. Röhmann-Spitzer reaction solution turned violet in presence of Cu, decreasing in intensity with decreasing Cu down to 0.1 ppm. More dilute Cu solutions -- down to 0.00005 ppm -- should show some color, although such dilutions were not tested. Pfeiffer-Kadlitz reaction did not provide color intensity in proportion to Cu content. They obtained some color reaction with Cu of 10 ppm and 0.3 ppm. They concluded that this indicator did not show sensitivity attributed to it by Pfeiffer and Kadletz and was inferior to Röhmann-Spitzer indicator. They contacted aq. dest. in vitro with chemically pure electrolytic Cu and pure CuO. Various gases were added to water. Activated waters were then tested for bactericide with inoculations of *B. paraty.*-A 24-hour agar culture suspension, contacted 24 hours at room temperature in dark, plated in agar and counted after 24 and 48 hours of incubation. They reported definite parallel between Cu dissolution and existence of oligo. activity in water. Oxygen was found to be one element, presence of which was necessary for activating aq. dest. Bu Cu did not activate aq. dest. in an atmosphere solely

of O_2 or H_2 , not even with 2 months' contact; neither did CuO nor Cu_2O with 1 month's contact. Latter did activate aq. dest. energetically in presence of CO_2 . They accepted theory that oligo. is caused by solution of metal. Found 0.3 ppm Cu killed 1000/cc of *B. paraty-A* in 24 hours.

86. ADSORPTIVE DISINFECTION IN THE PRESENCE OF OTHER ADSORBENTS (in German), H. Bechhold and R. Reiner, Zts. f. Hyg. u. Infek., 96:17 (1922). Investigated carbons impregnated with Ag salts. Concluded that activity of insoluble disinfectant such as metalized carbon is weakened by presence of finely divided, insoluble, indifferent substances, and by surface indifferent material. Combination of 2 practically insoluble disinfectants is not additive, if adsorptive surface remains constant; decrease in activity was also observed. Finely divided solid disinfectants and surface-active disinfectants interfere with each other's activity.

87. OLIGODYNAMIC ACTION OF SILVER (in German), R. Doerr and W. Berger, Biochem. Zts., 131:351 (1922). Deactivated Ag metal by heating to melting point in Bunsen flame. Maintained such deactivation to be purely physical process and varying with temperature. Ag metal was made oligo. active by heating in strong air blast for short time, which produced Ag compounds on surface. Silver compounds which did not dissociate to give free Ag ions, but which left Ag as part of another compound ion, were very weak disinfectants. Thus, Kronig and Paul showed $KAg(CN)_2$, dissociating to K and $Ag(CN)_2$, to be much weaker than $AgNO_3$, $AgClO_3$, etc. Found that oligo. active Ag surfaces and activated water were rendered inactive by $KAg(CN)_2$. That aq. dest. absorbs Ag ions from Ag surfaces was demonstrated chemically by Hönigschmid and Birkenbach (Ber. deuts. chem. Ges., 1921, p. 1883). Doerr and Berger observed that 21 samples of aq. dest. from Ag condensers contained 0.12 to 0.26 ppm Ag. They believed that oligo. was caused by amount of Ag ions or to ionizable Ag compounds, not to colloidal Ag or to separation of Ag compounds. Believed atmospheres of CO_2 or dry O_2 to be strong activators of Ag surfaces.

88. ON THE HEMOLYTIC AND COAGULATING ACTIONS OF METAL IONS (in German), E. Meneghetti, Biochem. Zts., 131:38 (1922). In previous paper (Arch. di Sci. Biol., 2:285, 1921) Meneghetti demonstrated that action of salts of Zn, Cd, Fe, Ca, Ni, Pb, Cu, Hg, Ag, Pd, Pt, and Au were fundamentally cationic, varying with their concentrations -- low concentrations producing hemolysis and high concentrations producing coagulation. The present paper dealt with continuation of his work. Working with salts of Ag and Hg he determined that hemolysis and coagulation depended on concentration of metal ions. Actions varied with degree of

dissociation of metal compound, those ionizing most strongly being most active, and those dissociating to metal complex ions least active. Activity varied with temperature, ion concentration, specificity of metal ion, etc. Hemolysis appeared after removal of agent from coagulated substance of blood cell, thereby reversing process. This indicated that metal was still present as ion in fixed blood corpuscle. He then assumed that coagulation was caused by formation of combination or of ionic protein adsorption product.

89. BIOLOGICAL STUDIES ON ADSORPTION FROM VARIOUS METAL SALT SOLUTIONS (in German), Friedrich Pichler and Artur Wörber, *Biochem. Zts.*, 132:420 (1922). Pichler and Wörber investigated adsorption by spores of corn smut (*Ustilago maidis*) in various salts of Ag, Cu, and Hg, dissolved in aq. dest. free from oligo. pollutions. Tests indicated that more Cu ions were adsorbed than SO_4 ions. Assumed that in the cell albumin, the COOH groups can take up positive metal ion to replace H ion, and NH_2 groups could take up acid radical. Spores treated with CuSO_4 washed repeatedly with aq. dest. until rinse water gave no indication for Cu. Then washed with cold 1 percent H_2SO_4 until no Cu was indicated therein. Then followed prolonged boiling of spores in 10 percent H_2SO_4 , and repeated washing until no Cu appeared in rinse water. Remaining spores were reduced to ash, and ash was dissolved in H_2SO_4 , which again showed definite indications of Cu. Their tests indicated that adsorption by spores followed no applicable adsorption formula. They also observed greater adsorption by dead spores than by live ones. Cu could not be removed completely from dead spores, but could be from adsorbents like charcoal, pulverized soapstone, etc. They observed adsorption of complex metal salts by live spores to be greater and faster than of simple salts. Explained this by assuming that through complex ion formation surface tension of solution is reduced, thereby promoting subsequent increased adsorption. Adsorption by live spores from Ag_2SO_4 was observed to be greater than of CuSO_4 , while HgCl_2 adsorption was less than of Ag_2SO_4 but greater than of CuSO_4 . Found adsorption to depend upon: whether metal is present as free ion or in a complex ion; whether complex ion is positive or negative; amount of ionization; and amount of adsorbing surface present. They believed that upon introducing spores to metal salt solution, spores first swelled, thereby changing spore adsorbing surfaces and forcing an increase in adsorption. Then followed decreasing adsorption velocity with penetration of adsorbed metal through cell wall, through protoplasmic membranes, into cell interior. Here took place "chemical adsorption," an irreversible binding of metal ion with cell contents in such manner as not to allow metal ion to be removable by boiling with strong acid. This "chemical adsorption" is property of interior protoplasm, of

protoplasma membranes and of various inclusions. They differentiated between physical death (sterilization) and death from poisoning with metal salts. Former was believed to increase adsorption, latter to oppose it, the protoplasma membranes remained semipermeable only when alive, thereby opposing entrance of metal ions into living cell.

90. ON THE ACTION OF METALS ON BACTERIA (in German), A. Schnabel, Klin. Wochs., 1:389 (1922). Schnabel reviewed previous literature. Emphasized that Arndt-Schultz law also covered stimulating effect on life by minimal doses of metals. Believed Saxl's "Fernwirkung" to be volatilization process.

91. ON OLIGODYNAMIC ACTION OF METALS (in German), Josef Schumacher, Biochem. Zts., 134:398 (1922). Schumacher described method of indicating Ag ions in solution by "leukomethylene blue."

92. LOHNER'S MARGIN AROUND STERILE ZONES AS EVIDENCE FOR ARNDT'S LAW (in German), W. Seiffert, Biochem. Zts., 129:50 (1922). Seiffert made detailed investigations of profuse growth (Löhner's) margins circumscribing sterile zones produced by germicides in solid media. Regarded this manifestation as indication of validity of Arndt's rule governing appearance of growth stimulation, narcosis, and death upon variation of concentration of germicide.

93. OLIGODYNAMIC ACTION OF METALS ON BACTERIA (in German), Karl Süpfle, Ztbl. gesam. Hyg., 1:129 (1922). Reviewed previous investigators and presented summary of their findings. Süpfle's work indicated that Saxl's "Fernwirkung" was caused by volatilization of germicidal agent, and was not new physical phenomenon. He cited Kieser thus: Cu is adsorbed strongly by glass and can not be removed by washing. Greatest part of Cu combines chemically with substance of glass to give difficultly but not totally insoluble Cu silicates. These can be given up to water later. Bacteria in water, with their enormous aggregate body surface, have greater adsorption capacity than does glass, and tear out Cu from it. Süpfle concluded that oligo. action rests on metal combination. There must be present dissolving substance and lytic medium. Action is affected by solution and diffusion factors. Adsorption by bacterial surfaces concentrates dissolved metal salts on them, and makes weak solution effective. Death follows adsorption.

94. SILVER-CARBON AND SILVER-BOLUS (in German), H. Bechhold, Munch Med. Wochs., 40:1149 (1923). Bechhold investigated adsorption of bacteria by various substances. Observed that adsorption increased with fineness of substance, and that proportionality disappeared when particle size approached that of bacteria -- 1 to

2 microns. Developed adsorptive substances that would not only retain bacteria upon their surfaces but would kill them as well. Found that boluses and charcoal covered with thin coat of Ag adsorbed more bacteria than uncoated. Ag-charcoal was twice as bactericidal as was Ag-bolus. Only 2 percent of charcoal or bolus needed Ag covering to prevent growth of adsorbed bacteria.

95. ON THE QUESTION OF OLIGODYNAMIC ACTION: INFLUENCE OF METAL COPPER ON BLOOD CATALASE (in German), M. Händel and E. Segall, *Zts. f. Hyg. u. Infek.*, 97:1 (1923). Händel and Segall investigated oligo. action of Cu on solutions of isolated blood -- catalase, the enzyme which decomposes H_2O_2 added to blood. They demonstrated that catalase action was retarded by bright Cu metal, either in dark or light; by glass activated by Cu. They developed curves showing quantitative effect of Cu metal and $CuSO_4$ on retardation of catalase action.

96. THE ROLE OF OXYGEN IN OLIGODYNAMIC ACTION OF METALS (in German), Kurt Herzberg, *Ztbl. f. Bakt.*, 90:113 (1923). Herzberg did not believe that oligo. bactericide of metals was caused by direct action of metal salt or metal ion, but that metals acted only as catalysts for oxidations and dehydrogenations. His tests of Cu coins embedded in agar infected with *B. coli*, under both aerobic and anaerobic conditions afforded him no conclusions as to effect of O_2 . Observed that $HgCl_2$ in absence of O_2 gave no sterile zones, and same for colloidal Ag in the medication Kollargol. Found that *B. coli* in absence of O_2 could tolerate ten times Kollargol dose than in its presence. With decreasing dose effect of O_2 became more pronounced. These observations led him to conclude that in oligodynamic dilutions, metal ions adsorbed by bacteria do not produce death directly or by formation of metal complexes in cell. Rather, they act as intermediaries -- catalysts -- only in presence of molecular oxygen. Bactericide then occurs either by direct oxidation by condensed O_2 , or, active O_2 draws to itself unstable H from cell substance in manner of dehydrogenation, with intermediate step of H_2O_2 production before final product of H_2O . Bactericide is then effected actually by accumulation of oxidation products in cells. Only "gross-poisoning" by metals in high concentrations is relatively independent of presence of O_2 . His tests with coins of Cu and Ag in agar plates led him to believe that bactericide produced was "gross" metal salt poisoning, not oligo.

97. STUDIES ON SALT ACTION; VI STIMULATING AND INHIBITIVE EFFECTS OF CERTAIN CATIONS ON BACTERIAL GROWTH (in English), Margaret Hotchkiss, *J. Bact.*, 8:141 (1923). Hotchkiss investigated effects on *B. coli* *commun.* by chlorides of: (a) Na, K, Li, NH_4 , Sr, Mg, Ca, Ba, Mn, Ti, Sn, and (b) Ni, Tl, Cu, Fe, Zn, Co,

Pb, Al, Ce, Cd, and Hg. Used 1 percent peptone solution medium; estimated bacteria by relative turbidity determinations. Toxicity doses were determined after 3 days' incubation and sterility then checked by streaking agar slants with loop of treated culture. Observed that generally salts of first group above, or those commonly found in protoplasmic environment were non-toxic. Salts of second group of heavy metals prevented growth in concentrations varying from 10^{-2} to 10^{-5} M. These salts stimulated growth in concentrations varying from 10^{-3} to 5×10^{-7} M.

98. INHIBITION OF AMYLASE BY SILVER SALTS AND OTHER HEAVY METALS (in English), Gensichi Mori, J. Biochem. (Tokyo), 2:117 (1923). Found that 1.25×10^{-8} M of AgNO_3 decreased activity of enzyme amylase by 14 percent. When dilution was greater than 6×10^{-8} M the inhibition became directly proportional to Ag salt concentration. For large salt concentrations, inhibition varied with square of salt concentration. By addition of H_2S to enzyme solution treated with AgNO_3 , he could recover 87 to 88 percent of amylase activity in every case, thus indicating enzyme was not destroyed by dilute AgNO_3 . AgCl_2 was 1.23 times as effective as AgNO_3 , $\text{AgBr} = 0.106$, $\text{AuCl} = 0.05$, $\text{CuSO}_4 = 0.03$, lead acetate = 0.0007 times as effective as AgNO_3 . He concluded that heavy metals inhibit enzyme activity. Enzyme is not destroyed; it is only rendered inactive temporarily and recovers activity upon removal of inhibitory substances.

99. DETERMINATION OF MOLECULAR DISSOLVED SILVER, E. (in German), Karl von Neergaard, Arch. Exper. Pathol., 100:162 (1923). Described method for determining free Ag ions and molecular dissolved Ag in colloid mixtures, as well as colloidal Ag by potentiometric titration.

100. OLIGODYNAMIC ACTION OF METALS AND METAL SALTS (in German), Paul Saxl, Wien. Klin. Wochs., 36:551 (1923). Saxl presented arguments to refute his critics, Doerr and Berger, on the question of what is the essential nature of oligo. Observed that a clean Ag wire was not exhausted in oligo. activity after 28 days in aq. dest., or after 4 days in serum; but did find Ag exhausted after 24 hours in aq. dest. with bacteria, or in serum with bacteria. Concluded that colloids do not exhaust oligo. action. H_2SO_4 removed Ag activity by formation of Ag_2S on surface.

101. MICROCHEMICAL INVESTIGATIONS ON THE PENETRATION OF SUBLIMATE INTO THE BACTERIAL CELL (in German), K. Süpfle, Arch. f. Hyg., 93:252 (1923). Süpfle was interested in defining mechanism of sublimate action on microorganisms. Gegenbauer (Arch. f. Hyg., Vol. 90) concluded that part of HgCl_2 molecules bound to albumin by exchanging Hg atom for H atom of albumin substance resulting

in protein-Hg and protein-HCl complexes. Schumacher (Ztbl. f. Bakt, Vol. 89), on basis of work with yeast, concluded that sublimate combined with nucleic acids, not albumins. Previously Süpfle with Miller and Englehardt demonstrated that sublimate was adsorbed only by bacteria cell membrane; then by use of bone charcoal, sublimate was removed sufficiently from seemingly dead bacteria to permit their subsequent revival in suitable media, and their further multiplication. Working with *B. anthracis*, Süpfle now treated them with 0.1 to 0.2 percent HgCl_2 at 18 C for short time. Bacteria removed from disinfectant and H_2S solution added to them. Microscope revealed profuse black grains in cells, identified as HgS deposit. Bacteria showed no other morphological changes. Very great cell changes were revealed only after treatment with stronger (1 percent) HgCl_2 solution at 37 C for longer time. These became thicker, either with or without addition of H_2S . Believed this thickening was caused by combining of Hg with constituents of cell membrane. Further treatment of such bacteria with iodine-alcohol solution caused immediate disappearance of swelling with resumption of normal bacterial appearance. Attributed this to dissolution of Hg-membrane-constituent compound to form HgI . Swellings of bacteria were observed to occur sparingly after 6 hours' contact with 1 percent HgCl_2 ; only a part of *B. anthracis* were thus affected after 4 weeks' contact. His work indicated that Hg did penetrate bacterial cell membranes, but he provided no answers to question he propounded: was such penetration pre- or post-mortem?

102. ON THE NATURE OF OLIGODYNAMIC AND OTHER SIMILAR SENSITIVE PHENOMENA (in German), Maximilian Fischer, Arch. f. Hyg., 94:215 (1924). Fischer investigated oligo. action of metals on bacteria, and found no bactericide for any except Hg and Ag, with Hg more oligo. None found either for used coins in agar, or for chemically pure Ag discs. Ag heated in flame produced sterile zone once, another time none. Ag washed with dilute acid showed no appreciable increase of oligo., contrary to Doerr. AgNO_3 in presence of Ag acted regularly. AgNO_3 in nutrient agar plate, dissociated, formed AgCl with NaCl of medium, and agar gave momentary acid reaction. Believed that oligo. was essentially simple chemical solution and diffusion.

103. REMARKS ON THE ACTION OF MERCURY (in German), Wolfgang Heubner, Biochem. Zts., 145:431 (1924). Heubner speculated on action of Hg, thus: One must assume that reaction between Hg ions and cell albumins is merely salt formation. It is necessary that Hg ions join with some protein acid, in which positive charge of albumin satisfies negative valence of chloride of sublimate. Not too much emphasis must be put on such simple salt formation. Some metals will form complexes, by joining molecules bodily with

other atoms or atom groups, without formation of intermediate Hg ions. Albumin can satisfy this complex forming tendency of HgCl_2 . Believed that not enough information existed to give quantitative expression to such formation of complexes.

104. EFFECT OF CERTAIN CATIONS UPON BACTERIAL GROWTH (in German), Margaret Hotchkiss, *Ztbl. gesam. Hyg.*, 7:395 (1924). Abstract of Hotchkiss' paper in *J. Bact.* 8:141, 1923, q. v. supra.

105. ON THE THEORY OF SPORE DISINFECTION HEAVY-METAL SALTS (in German), Walter Liese, *Zts. f. Hyg. u. Infek.*, 102:517 (1924). In previous paper Liese pointed out that in chemical disinfection, only irreversible changes in cell can indicate death of cell. Purely physical action of adsorption does not result in death, but only retards development through masking bacterial surface from contact with its nutrient medium. Should such adsorbed occlusions be removed as by washing, cells resume their development. Prolonged retention of such occlusions, however, can induce secondary changes in cell, leading to death. With spores one cannot depend upon death from adsorption alone, since their respiration is greatly reduced. At this time he worked with AgNO_3 on dried spores of *B. subt.* A 1.25 percent solution was hardly effective under at least 80 hours' contact. A 15 percent solution produced death of spores in 22 hours. Believed that with low concentrations and long contact time, Ag ion is adsorbed, diffuses slowly into cell interior, combines with nuclear substances, with injury to cell resulting. With stronger solutions, adsorption and diffusion is greater, resulting in direct physical-mechanical damaging of cell. Observed ammoniacal AgNO_3 solution much weaker than AgNO_3 , thus substantiating Krönig and Paul. Believed this was because Ag is not in the form of free ion but in complex $\text{Ag}(\text{NH}_3)_2$. Concluded that activities of metals differ because of their different solubilities in lipoids. HgCl_2 is more bactericidal because more soluble in lipoids, while AgNO_3 is insoluble in lipoids.

106. OLIGODYNAMIC ACTION AND HEMOLYSIS (in German), Dora Rosenberg, *Klin. Wochs.*, 3:2056 (1924). Rosenberg investigated hemolytic action of Au, Ag, Cu, Al, Sn, Zn, and Fe, on erythrocytes in physiological NaCl solution. Only Cu was observed to be hemolytic. All other metals remained inactive even after 5 days' contact. No oligo. effect on erythrocytes could be transferred from glass.

107. SILVER-CHLORIDE AND SILICIC ACID (in German), H. Bechhold, *Munch. Med. Wochs.*, 72:1625 (1925). Finely divided silicic acid coated with Ag Cl (0.5 percent) showed high adsorbing and bactericidal power on *B. coli*, paraty., and Staph. in agar plates.

Activity exceeded that of coated or uncoated carbons.

108. ON THE HEMOLYTIC ACTION OF VARIOUS METAL POWDERS (in German), A. Kurokawa, *Zts. Immunfor.*, 44:127 (1925). Kurokawa combined adsorption with oligo. problems by working with powders of Au, Cu, Ag, Al, Mg, Zn, and Fe. With these Kurokawa sought to analyze hemolysis. He believed that many finely divided substances are hemolytic, and that such hemolysis is retarded by presence of gelatinous substances like serum, agar, gelatin, albumin, etc. Reviewed work of previous investigators of oligo. bactericide. His work indicated that Ag-activated water with and without NaCl killed *B. typhi.*, paraty.-A and -B in agar plates after 18 hours' contact. The NaCl appeared to make activated water more bactericidal to *B. typhi.* and paraty.-A, than without NaCl; but reverse was observed for *B. paraty.-B.* He presented test data to compare relative oligo. activity of Ag and $HgCl_2$, but this reviewer could find no conclusive indications therefrom. Observed that oligo. doses were 0.5 percent for Cu, Ag, Al, Mg, Zn, and Fe, but only 0.1 percent solution of Au was required. Following contact periods were observed to be necessary for bactericide: Ag, 22 hours; Fe, 3 days; Al, 4 days; Au, 4 days; Zn, 11 days; and Cu and Mg, not even after 14 days.

109. A CONTRIBUTION TO THE THEORY OF SILVER SALTS ACTION (in German), Karl von Neergaard, *Dermat. Zts.*, 43:266 (1925). Was concerned with analysis of various Ag therapeutic preparations. Determined their physical and chemical characteristics, with examinations by microscope, ultramicroscope, tyndall meter, and electropotentiometer. In all, he found Ag in various forms ranging from molecular dispersions in colloidal media, through chemically bound Ag, to pure colloidal metal Ag. In presence of NaCl greatest portion of Ag was found as AgCl and remainder as Ag salt-albumin complexes, and as colloidal Ag. Protecting colloids of medium prevented deposition of AgCl precipitate. Without NaCl, largest portion was found as molecular disperse. Colloidal Ag was found very often as a-microns (under 5 millimicrons, invisible in the ultramicroscope), and in some preparations partly as ultramicros (not visible in ordinary microscope, but visible in ultramicroscope). Cited Lottermooser and Mayer to explain action of AgCl. Ultramicroscopic AgCl particle adsorbs to its surface an ion in this manner: $(AgCl) \cdot Cl + Ag^+$; thus, AgCl particle becomes negatively charged complex ion, and at the same time produces free Ag ion. Conversely, NaCl added to solution of $AgNO_3$ forms positively charged complex ion and free Cl ion, thus, $(AgCl) \cdot Ag^+ + Cl^-$. Neergaard discussed action of Ag in body. However, following is of interest. The Ag albumin compounds are precipitable, non-reversible, and insoluble in excess of coagulant. Precipitation can occur as mere neutralization of charges in conformance with

adsorption isotherms, thus: $\text{Albumin}^{++} + \text{Zn}^{++} = \text{Albumin} \cdot \text{Zn}$. Silver albumin compounds can form only after Cl is satisfied by Ag and excess of Ag has been able to diffuse through cell membrane.

110. THE SCIENTIFIC BASIS OF SILVER THERAPY (in German), Karl von Neergaard, Med. Wochs., 55:661 (1925). Primarily concerned with intravenous Ag therapy. Determined physical characteristics of colloidal Ag. Believed bactericide by colloidal Ag to be very doubtful, at least in doses of Ag medicants. Discussed action of Ag in body. Doubts whether in presence of such small biological chlorides concentration AgCl would form such complexes as $\text{Na} \cdot \text{Ag} \cdot \text{Cl}_2$ or $\text{Na}_2 \cdot \text{Ag} \cdot \text{Cl}_3$. Albumin has some influence on solubility of Ag. Working with pure solutions of albumin and globulin he found that Ag ions are bound primarily by albumin. Results indicated not chemical binding but rather adsorption of Ag ions conforming with Freundlich isotherms - proportionally greater adsorption with lower concentrations of Ag. He also observed forming of Na-Ag-Cl complexes paralleling binding of Ag to albumin, and in equilibrium with each other. Albumin solutions attained higher Ag ion concentrations than did electrolytes or globulin solutions of like chloride content. Observed that for inhibiting growth of *B. coli*, required 13 gamma Ag ions per liter in aq. dest., while in bouillon only 0.19 gamma was required. He explained this by statement that bouillon permitted formation of Na-Ag-Cl complexes which were also bactericidal. Concluded that for bactericide what is more important is concentration of disinfectant on bacteria rather than in solution. Solubility of Na-Ag-Cl complex is sufficient to make it bactericidal also. Adsorption of Ag ions by albumins increases amount of Ag going into solution from Ag source. Thus, with greater concentrations of bacteria, solubility of Ag increases with need for bactericidal action.

111. EXPERIMENTS ON INTRAVENOUS SILVER THERAPY (in German), Karl von Neergaard, Arch. Exper. Pathol., 107:316 and 108:295 (1925). Investigated effect of body electrolytes on concentration of Ag ions. Investigated further reaction of Ag with proteins. Potentiometric investigations led him to conclude that formation of AgCl and Ag-albumin complexes are simultaneous, parallel events. Ag adsorption by albumin conformed to Freundlich isotherms. Assumed that albumin acted as adsorbent, and AgCl as adsorbate. With procedure of adsorption, Ag ion concentration in original solution is lowered, promoting still further dissolution of Ag from its source; and as adsorbability of albumin gradually decreases through saturation of its valences, Cl ion concentration governs more and more until finally it determines maximum Ag ion concentration. Careful potentiometric investigations indicated that Ag ions are not bound to globulin. He concluded that fact that Ag combines with albumin provides new point

of attack for more exact investigation of mechanism of toxic and disinfecting action of heavy metals. He could not establish any relation between Ag adsorption by albumin and temperature; or that non-specificity of adsorbents was applicable to albumin hydrophylic colloids as well; or of reversibility of adsorption. Technical difficulties prevented his quantitative determination of proportions of Ag bound to albumin and concentration of Na-Ag-Cl complexes. He summarized process of Ag and albumin action thus: Ag ions form with NaCl of organism complexes Na-Ag-Cl. These have tendency to decompose into their constituents when Ag ion concentration becomes small compared to complex-bound Ag. The albumin then pulls free Ag-ion to it. This reduces free Ag ion concentration in solution causing further decomposition of Ag complex. This balancing process continues until adsorptive capacity of albumin for Ag is decreased so much that it can no longer promote decomposition of even weakly bound AgCl_2 complex. Thus is reached equilibrium between tendency on one side to bind free Ag ions to albumin, and on the other side to bind Ag-complex ions to Cl_2 . Since it appears that adsorption of Ag by albumin is principal cause of cytotoxic action, power of this action depends upon kind of complexes formed. If strong complex like $\text{KAg}(\text{CN})_2$ is formed, inability of Ag to split off prevents occurrence of adsorption, and cytotoxic action remains absent. Bactericide depends greatly on stable complex formation. It is possible that some Ag complexes are adsorbed bodily by albumin as complex ions.

112. EXPERIMENTS ON INTRAVENOUS SILVER THERAPY (in German), Karl von Neergaard, Arch. Exper. Pathol., 109:143, 164 (1925). Investigated action of AgNO_3 on *B. coli* and *Staph. aureus*. Found that 340 gamma AgNO_3 /l. was enough to kill bacteria while 100 gamma definitely inhibited bacterial development; both bacteria required same bacteriostatic dose but *Staph. aureus* required greater dose and more contact time for bactericide. Observed much less Ag ions were required for bacteria in bouillon than in aq. dest. He concluded that not only free Ag ions are bactericidal, but that Ag in some form of non-dissociated compound can also be active. Also, action of Ag in physiological media must be different than in aq. dest. Potentiometric investigations with *B. coli* suspensions treated with AgNO_3 indicated binding of free Ag ions to bacteria, corresponding to adsorption and loss of charge on bound Ag ions. Using meat bouillon to simulate physiological solution medium for bacteria, Ag ions were adsorbed by bacteria in spite of presence of NaCl. Thus, it was demonstrated that electrolytes did not hinder adsorption. Variation of pH did not affect action. He then concluded that binding of Ag on bacterial albumin depends quantitatively on Ag ion concentration of solution. Force promoting adsorption is limited to that with which Ag ion seeks to cling to inorganic complexes like $(\text{AgCl})\cdot\text{Ag}$.

or Na-Ag-Cl complexes. Adsorptive power of bacterial surfaces is much greater than force required to maintain Ag binding on inorganic complexes. The Ag ions are then adsorbed, further decomposition of the complexes in solution is promoted, and bacterial surfaces are able to adsorb sufficient Ag ions to result in disinfection. By potentiometer he was able to indicate presence of as much as 55 gamma Ag ions per l of Ag-activated water. He observed no oligo. action of Ag covered with Ag₂S or of Ag surfaces cleaned with KCN.

113. THE BACTERICIDAL TELERGY OF METALS (in German), F. Pfab, Mitt. Grenzgeb. Med. u. Chir., 38:575 (1925). Pfab dealt with therapeutic application of Ag, with doubtful contribution to subject of oligo.

114. AN ATTEMPT TO EXPLAIN THE MANIFESTATION OF OLIGODYNAMIC ACTION (in German), J. Voigt, Klin. Wochs., 4:2386 (1925). Voigt concerned mainly with determination of diffusion of Hg in solid gelatin media.

115. BACTERIAL FILTERS (in German), H. Bechhold, Ges. Ing., 49:113 (1926). Bechhold tested metal impregnated filter elements of porcelain and of diatomite of 10 to 3.8 microns. Found hardly any influence of impregnation on filter rate, although impregnation decreased larger pore sizes. Gave incomplete bacteriological examination data. Concluded that impregnation can make filters bacteria retentive and prevent growth of such retained bacteria, giving sterile water for many months. Best for medium-pore filters.

116. THE BIOLOGICAL SIGNIFICANCE OF THE OLIGODYNAMIC ACTION OF METAL AND ITS RELATION TO HOMEOPATHY (in German), A. Buschke, F. Jacobsohn, and E. Klopstock, Munch. Med. Wochs., 73:437 (1926). A continuation of their work, demonstrating that oligo. action depends upon dissolution into ionized metal compounds from metal oxidation products formed in presence of air. In infected medium containing albumin, non-ionizing metal salts produced no sterile zones. Salts must be lipoid-soluble for disinfection.

117. BACTERICIDAL ACTION OF CADMIUM COMPOUNDS (in English), E. A. Cooper and L. I. Robinson, J. Soc. Chem. Ind., 45:321 (1926). For bactericide doses Cooper and Robinson found: Cadmium salts averaged 1:75,000; AgNO₃, 1:300,000; and HgCl 1:400,000.

118. INFLUENCE OF LIGHT ON EFFECT OF SILVER ON CONVOLUTA (in French), Anna Drzewina and Georges Bohn, Compt. Rend. Acad. Sci., 186:677 (1926). Convoluta in water in test tube with strip of Ag immersed therein were exposed to diffuse sunlight; worms

were dead in few minutes, but those in tubes kept in dark with all other conditions same were found to survive even after 7 hours. They also observed that reactivation of Ag could be accomplished in 1 hour in sunlight but in 6 hours in dark.

119. ON A NEW METHOD OF MICROCHEMICAL DETERMINATION OF SILVER (in German), F. Feigl and J. Pollock, Mikrochemie, 4:185 (1926). Feigl and Pollock described method of Ag determination using rhodanin (sulfurcyanide compound).

120. DRUG FASTNESS OF ORGANISMS TO VARIOUS GERMICIDES (in English), P. D. Meader and W. A. Feirer, J. Infec. Dis., 39:237 (1926). Meader and Feirer worked with B. typhi, 3 strains of B. coli, and with B. lactis aerog. They observed definite drug fastness (tolerance) developed to AgNO_3 , mercurochrome, and other chemical germicides. Highest degree of tolerance was shown to heavy metals, except by B. typhi. All bacteria of the coli-typhi group exhibited wide variations in their behaviour to various germicides.

121. ON THE INCREASE OF ANTISEPTIC ACTION OF SUBLIMATE IN ACID SOLUTIONS (in German), W. Nagel, Zts. f. Hyg. u. Infek., 105:495 (1926). Nagel worked with B. coli, Staph. aureus, and B. anthracis spores. He found that addition of HCl increased bactericide of HgCl_2 severalfold, excepting on the anthrax spores. $\text{Hg}(\text{NO}_3)_2$ was similarly activated by HNO_3 . Found that NaCl decreased activity of HgCl_2 . Presumed that Cl ion was not responsible for different actions of HCl and NaCl. Moreover, both produced same Hg complex, thus: $\text{HgCl}_2 + 2\text{NaCl} = \text{Na}_2 \cdot (\text{HgCl}_4)^{-}$, and $\text{HgCl}_2 + 2\text{HCl} = \text{H}_2 \cdot (\text{HgCl}_4)^{-}$. Therefore, it must be H ions bound to Hg complex that caused strengthening of HgCl_2 action, varying according to H ion concentration and being greater with greater dissociation of acid. He observed that HCl made Hg_2S bactericidal, and ascribed this activation to the H ions. He thought that possibly the H ions worked on albumins in protoplasmic membranes of cell, making them more permeable for succeeding Hg which must be available as cations, not in complex anion. Hg ions are active agents in bactericide.

122. REMARKS ON THE WORK OF DR. VON NEERGAARD (in German), Paul Saxl, Arch. Exper. Pathol., 111:305 (1926). Saxl maintained that use of Ag_2O was not indicated for study of oligo. action when considering its relatively slight solubility. He re-emphasized fact that glass walls adsorb Ag in large proportions.

123. ACTIVATION AND INACTIVATION OF THE OLIGODYNAMY OF SILVER (in French), J. C. Felipe and Th. Martin, Compt. Rend. Soc. Biol., 97:1364 (1927). Active Ag sheets were kept submerged in

running water (pH 6.9); 15 to 20 hours was enough to deactivate both Ag sheets and commercial Ag salts. Were able to activate Ag sheets by: prolonged exposure to air, or in atmosphere of O_2 or CO_2 ; by dilute acid; rapid heating to glow in Bunsen flame; heating in hot air stove at maximum temperature of 80 C for 1 to 2 hours. Found no effect by light or dark.

124. ON THE THEORY OF DISINFECTION: MICROCHEMICAL INVESTIGATIONS ON THE ACTION OF HEAVY METALS AND DYES ON LIVING BACTERIA (in German), M. Gutstein, Ztbl. f. Bakt., 104:410 (1927). Reviewed work of previous investigators on localization of bactericidal agents in cells. Gutstein attempted to show locale of action of heavy metals and dyes in bacterial cells by various chemical and staining techniques. With $K_3Fe(CN)_6$ as reagent, resulting coloration demonstrated Fe taken up by live yeast from $FeCl_3$ to be localized in both protoplasma membranes. NaOH or NH_3 showed Hg to lodge in inner membrane. Hematoxylin dyeing demonstrated Fe to localize in both membranes of live yeast cells, and in inner protoplasma membrane in *B. anthracis*, pneum. Friedlander and in Strept.; anthrax spores showed same localization of Fe. Dye indicated $CuCl_2$ to lodge in both membranes of live yeast cells, *B. anthracis* and their spores, and in inner membrane of other bacteria. Hematoxylin indicated localization of Bi, Sn, Zn, Pb, Al, and Ag in various parts of bacterial endo- and ectoplasm. Analogous work on localization of stains and dyes also indicated parts of bacterial anatomy involved, especially of living cells. He concluded that heavy metals always concentrate in protoplasma membranes. He assumed, therefore, that primarily chemical substances in membranes are affected by heavy metal disinfectants. He identified these as lipoids containing phosphatide. Evidence by previous investigators indicated to him that ensuing chemical disinfection does not proceed through mere adsorption of metal by ectoplasmic substances, but rather through chemical binding and chemical change. Suple's reviving of sublimate treated bacteria by strong adsorbents did not necessarily prove reversible adsorption process. Adsorbents can remove Hg by chemical change or by ion exchange also. He agreed with Liese and Mendel that adsorption is stage preliminary to chemical reaction between metal and ectoplasma substances. Gutstein's examinations made him postulate the following action: $AgNO_3 + \text{Phosphatide} = Ag\cdot\text{Phosphatide} + HNO_3$. Assumed that death of bacteria was caused by disturbance of respiratory processes resulting from action of metals on phosphatides. Re-emphasized Liese and Mendel's statement that oligo. activity depends primarily on bacterial surfaces and much less on its species.

125. THE EFFECT OF METAL POWDERS UPON THE DISINFECTION BY METAL SALTS (in German), Mashiko Kuroya, Ztbl. gesam. Hyg.,

14:565 (1927). Investigated action of chlorides of alkaline earths and of heavy metals on *B. typhi*. in bouillon cultures. Observed that addition of metal powder to metal salts increased oligo. action.

126. THE OLIGODYNAMIC ACTION OF SILVER (in French), R. Wernicke, I. Dortzenbach, and J. de la Barrera, *Compt. Rend. Soc. Biol.*, 96:896 (1927). Their laboratory work indicated that Ag in presence of H_2 water could not activate water even with contact of 2 months. It was made strongly active in presence of CO_2 , sensibly active in air deprived of carbonic acid, and strongly active in air mixed with carbonic acid.

127. ON THE INFLUENCE OF METAL SALTS ON THE DEVELOPMENT OF BACTERIA (in German), P. H. Andresen, *Ztbl. f. Bakt.*, 105:444 and 104:392 (1928). Andresen was primarily concerned with thesis that oligo. action of metals on bacteria was substantially influenced by physico-chemical makeup of media. By careful electropotentiometric investigations he analyzed effects of varying concentrations of $AgNO_3$ on *B. coli* in liquid media with various constituents. He observed that free Ag ion concentrations were lower in culture solutions than in water for identical Ag doses. This indicated that organic matter of media either adsorbed or combined chemically with Ag ions. Concurrent microscopic examinations indicated that bacteriostatic doses of Ag ions were 10^{-8} to 1.5×10^{-10} for bouillon cultures, 0.6×10^{-8} to 8.0×10^{-10} for 1/2 percent peptone media; 0.3×10^{-8} to 2×10^{-11} for 2.5 percent peptone plus 0.2 percent glucose media; and 10^{-7} for non-albuminous media. Addition of $10^{-3}M$ to $2 \times 10^{-4}M$ of $Na_2S_2O_3$ solution decreased absorption of Ag ions by media to one-seventh. He concluded that Ag could inhibit bacterial growth only in amounts above minimum value representing amount of Ag required to combine with nutrient medium, plus amount to be adsorbed by bacteria, plus some excess. Believed poisoning action was solely because of the Ag ions.

128. ON SILVER-SPECIFIC REAGENTS AND ON A NEW SENSITIVE SILVER INDICATOR (in German), F. Feigl, *Zts. anal. Chem.*, 74:380 (1928). Feigl found that rhodanin in acid solutions formed insoluble precipitates with salts of Ag and Hg. For Hg precipitate was not Hg-rhod. but Hg-sulfo salts. In alkaline solutions rhodanin precipitated almost all heavy metal ions as colored precipitates.

129. EXPLANATION OF OLIGODYNAMIC ACTION (in German), H. Freundlich and K. Sollner, *Biochem. Zts.*, 203:3 (1928). Activated various waters by contacting 100 cc of each 72 hours by Ag sheet of 40 sq cm surface. Distilled water had absorbed 28 gamma Ag/l;

tap water 24 gamma. Algecide in these activated waters was rapid. The algae took up 79 percent of Ag in water. In clean sterile beakers of ordinary glass they placed 150 cc of tap water with AgNO_3 to give 33 gamma Ag/l., and replaced with same 4 times in 3 days. Thereafter, neutral water activated by glass beaker could kill 90 percent of algae in 72 hours. Explained this as caused by desorption of Ag ions from glass previously adsorbed from AgNO_3 . They observed that Ag was more firmly stored in glass than in quartz.

130. NEW METHODS OF WATER STERILIZATION (KATADYN) (in German), Georg A. Krause, pamphlet published by Bergmann, Munich 1928. Developed form of Ag to provide optimum activity through optimum ratio of Ag surface to Ag volume. This was spongy lamellar metallic form produced from pure Ag to which was added an activating metal below Ag in electropotential series, such as Pd or Au. This he named "Katadyn Silver"; could be used as linings for flasks, as impregnations on filter elements, or as coatings on sand or other material. Oligodynamic Ag exhibited catalytic activities. Water contacted with Ag for several weeks indicated absorption of 15 gamma Ag/l. This water diluted down to 0.15 gamma was still oligo. Tested various concentrations of *B. coli* suspensions with 10 g Ag/l in various forms and observed that Katadyn Ag killed large concentrations of *B. coli* in matter of hours and minutes, compared to days with other forms of Ag. Given quantity of water activated by contact with same given quantity of various forms of Ag for same given time and tested for bactericide demonstrated much greater oligo. activity for Katadyn Ag. Activated water stored 13 months still showed undiminished bactericide. For bacterial count, 1 cc of bacterial suspension was placed in gelatin or agar plates and incubated 5 days in gelatin or 3 days in agar, then counted. For testing sterility, 10 cc of bacterial suspension was introduced into Eijkman liquid nutrient medium, and after 24 hours preliminary observation was made. Then inoculation from this medium was made in endoagar and after another 24 hours final observation was made. Found that 50 g quartz sand covered with 5 g Ag in 500 cc of water produced sterility in 2 to 3 hours for 1 million/cc of *B. coli*, proteus, paraty. A and B, typhi. abdominalis, dysent., Shiga-Kruse, dysent. Flexner, Pneumoco. types I, II, and III, mixture of 12 strains of hemolytic Strept., and mixture of 8 strains of Staph. Most resistant (3 hours' contact) were *B. coli*, dysent., Flexner, and Staph. *B. tuberc.* suspensions prepared with Katadyn-activated water, injected in live guinea pigs, produced no tuberculosis in them in 3 months, whereas, 10 control guinea pigs injected with non-oligo. suspensions of *B. tuberc.* were heavily tubercular in $2\frac{1}{2}$ months. Water with 1 to 2 million *B. coli* per cc was run through 500 g quartz sand covered with 5 g Katadyn Ag,

40 liters daily for 3 months. Bacteria were strained out and killed in filter bed, and residual Ag was imparted to filtrate. Activity remained undiminished at end of this time. Highest filter rate imparted sufficient residual Ag to be able to kill after inoculation of 2 million/cc in 3 to 4 hours. Obtained analogous results with Berkefeld filters, walls of which were impregnated, or interiors of which were filled with Katadyn Ag. Found no inhibition of oligo. bactericide by 0.2 percent NaCl, 0.2 percent MgO, 0.2 percent KI, 0.1 percent FeCl_3 , 0.3 percent CaCO_3 , 0.1 percent MnSO_4 , 0.2 percent bouillon, 0.01 percent serum, and 0.01 percent glucose. Presence of iron in activated water did retard activity slightly. With an Ag-coated sand filter bed, initial run with 700,000 bacteria/cc gave sterile filtrate after standing from 24 to 48 hours. After 52,000 l throughout, filter gave sterile water in 24 hours from initial 500,000/cc; and in 48 hours after 98,000 l throughout. Sterilization was stated to be independent of temperature.

131. ON THE OLIGODYNAMIC ACTION OF METALS (in German), Bruno Pfab, Munch Med. Wochs., 75:1917 (1928). Produced sterile zones by Zn plates. Made contact photographs of emanations from Zn plates.

132. THE ADSORPTION OF BACTERIA AND ADSORPTIVE DISINFECTION (in German), J. Renner, Zts. f. Hyg. u. Infek., 109:1 (1928). Renner investigated bactericidal action of AgCl-silicate devised by Bechhold (1925). He found it to have good bactericidal effect on Staph. pyogen., but better on B. coli-typhi. group. Better results were obtained at incubator temperatures than at room temperature. He believed that AgCl coat on silicate improved bactericide through its solubility rather than because of any added adsorptiveness.

133. DISINFECTION AND GROWTH INHIBITION WITH COPPER SALTS (in German), J. Vignati and P. Schnabel, Ztbl. f. Bakt., 109:464 (1928). Vignati and Schnabel worked with Cu salts in effort to determine various characteristics of bacteriostasis and bactericide. By chemical methods they could remove Cu from CuSO_4 treated B. coli with sodium thiosulfate or sodium citrate. Demonstrated that this action of CuSO_4 on bacteria was reversible adsorption of Cu. This reversibility was observed to decrease with increasing contact time with CuSO_4 , CuCl_2 , and $\text{Cu}(\text{NO}_3)_2$. Staph. were more resistant to reversal than were B. coli. In further attempt to determine any chemical changes in bacteria caused by Cu salts, they made investigations with nephelometer. Previous investigators had shown that albumin coagulating agents added to bacterial emulsion increased nephelometric effect; and that this was not because of any resulting change in size of bacteria, but because

of change in dispersion of bacteria bio-colloids. Their work with 0.1 percent CuSO_4 solution on *B. coli* showed a change of nephelometric effect within 5 minutes, and 50 percent increase in Tyndall effect. Such sudden change was similar to effects of coagulating lipoids and albumins by addition of CuSO_4 . They observed further that mere adsorption of crystalloid on bacterial cell did not produce any change in nephelometric effect. Therefore, they assumed that Cu-ions had similar action on bacteria as on solutions of lipoids and albumins, namely, a microcoagulation of bacterial colloids evidenced by increased nephelometric effect. This change occurs in ectoplasma membranes, and prevents further diffusion of nutrients from surrounding medium to cell interior. This produces bacteriostasis, and can lead to death in 48 hours. If during this time Cu can be removed by some agent like sodium citrate, bacteria can be revived. Longer contact with Cu salt can result in penetration of Cu ion to cell interior and produce death. This can be hastened by use of higher concentrations of salts. Thus they maintained that bacteriostasis is preliminary stage to bactericide. Their nephelometric tests on normal and on lipid-free *B. coli* treated with 1 percent CuSO_4 for 1 hour demonstrated 50 percent increase in nephelometric effect for *B. coli* with lipoids, and 70 percent increase for lipid-free *B. coli*. This indicated that injurious effects of salts were localized on albumins rather than on lipoids, contrary to Gutstein's belief. However, they emphasized that changes in lipoids are not to be assumed of no importance, but rather of less importance than albumin changes.

134. RELATIVE IMPORTANCE OF ADDITIVE AND ANTAGONISTIC EFFECTS OF CATIONS UPON BACTERIAL VIABILITY (in English), F. A. Winslow and A. F. Doloff, *J. Bact.*, 15:56 (1928). All cations were observed to have same qualitative effects on bacteria, but differed quantitatively. Bivalent cations were 8 to 10 times more potent than monovalent, with Hg ions one thousand times more. All cations stimulated growth at low concentrations, probably because they increased permeability of bacterial membranes to nutrients of media; and inhibited growth at higher concentrations, probably because of rupture or some irreversible physical change in cell membranes. They observed that mixtures of salts of univalent and bivalent metals were additive in their effects on viability of bacteria.

135. NEW MEANS OF STERILIZATION (in German), Rudolf Degkwitz, *Klin. Wochs.*, 8:342 (1929). Reviewed work of previous investigators. By comparing oligo. effects on bacteria by metal placed in petri dishes, and by activated water, Degkwitz concluded that bactericide was significantly greater when metal remains in medium during contact period. Believed that oligo. effect was either

caused by chemical solution or by catalysis by metal. Suggested that for practical application of silver for sterilizing large volumes of water, it would be advisable to place treated water in large storage or flow-through basins containing Ag-bearing bodies, to increase bactericidal effect and decrease contact time.

136. THE MICRODETERMINATION OF SILVER IN OLIGODYNAMIC WATER (in German), Carla Egg, Schw. Med. Wochs., 59:84 (1929). Reviewed previous methods of microdetermination of Ag. Egg's technique involved electrolytic methods with micro-weighing, similar to Feigl's. Believed best reagent to be p-dimethyl-aminobenzaldehyde-rhodanin. She observed that Ag adsorbed by glass could also be determined by this method.

137. A CONTRIBUTION TO THE MICRODETERMINATION OF BACTERICIDE OF SILVER AND COPPER (book in German), C. Egg and A. Jung, Mikrochem. Pregl. (1929). Gave detailed description of their method for microdetermination of Ag or Cu. Drew attention to necessity for taking into consideration adsorption of Ag by chemical glassware. They could indicate presence of Ag of 1 gamma/l. In determining Ag adsorption by glass, they observed that AgNO_3 solution after 8 days' storage in glass had its Ag concentration reduced from 35.7 gamma/l. to 33.1 gamma. Saturated AgCl solution after 39 days in glass showed drop in Ag from 890 gamma/l. to 534 gamma. Investigated oligo. action on *B. coli* inoculated in agar plates, incubated 72 hours at 37 C, and observed growth for 120 hours. All glassware contacted with concentrated HNO_3 for 24 hours before cleaning, to remove adsorbed Ag. With AgNO_3 , AgCl , Ag_2CO_3 , AgCN , Ag_2O , and Ag stearates and palmitates they observed performances similar to that of pure metal if test Ag salts solutions had like amounts of Ag ions. These killed 100,000 to 500,000 *B. coli* per cc in 24 hours with Ag content over 40 gamma/l; produced sterilization frequently with 25 to 40 gamma; and decided inhibition of growth under 25 gamma. Colloidal Ag organic preparations required larger Ag amounts for bactericide, probably because of protective action by accompanying colloids. They were able to remove oligo. effect from activated water by addition of KCN. Found no oligo. action from Ag_2S . Also, $\text{Ag}_2\text{S}_2\text{O}_3$ proved weakly active; Ag concentrations of 21 to 2780 gamma/l. gave same slow growth inhibition. They determined Cu to be less active than Ag. Bactericide required 600 gamma Cu/l; certain sterilization required 550 gamma with 48-hour contact. Found effect of combinations of Cu and Ag to be additive. They obtained sterilization with 7.5 gamma Ag plus 108 gamma Cu/l.

138. STUDIES ON OLIGODYNAMIC ACTION OF METALS AND METAL SALTS ON BACTERIA UNDER VARIOUS OXYGEN PRESSURES (in German), Paul Hoffmann, Ztbl. f. Bakt., 114:216 (1920). Hoffmann investigated

effect of oxygen on oligo. action. *D. pneum-Friedländer* required 500 times collargol (colloidal Ag in organic colloids) concentration in agar without oxygen than with oxygen. Dose varied inversely with atmospheric O₂ content. Same effects of O₂ were observed with colloidal Cu and colloidal Au. However, AgNO₃, AuCl₃, and CuSO₄ showed same oligo. activities under either aerobic or anaerobic conditions.

139. OLIGODYNAMIC STERILIZATION OF DRINKING WATER BY KATADYN EQUIPMENT (in German), F. Konrich, *Ges. Ing.*, 52:804 (1929). Konrich worked with Krause's Katadyn-Ag-covered filter sand. He observed that such sand gave speedier bactericide than did other oligo. means, that much larger bacterial concentrations could be handled, and that time factor was very important. He observed no effects on oligo. by temperatures ranging from 20 to 37 C; but at 0 C he observed that for sterilizing 89,000 *B. coli*/cc with 10 g Ag/l required 24 hours at 0 C as against 4 hours at 20 C; for 0.1 g Ag/l, 48 hours at 0 C was required as against 5 hours at 20 C. Observed slight variations of sensitivity of various pathogens, with *Vib. cholera* and *B. dysent.* Shiga-Kruse most sensitive. After treating daily 400 to 600 liters of water with 10000 to 30000 bacteria/cc, with 200 g Ag-sand in 1 liter, for period of 3½ months, found no diminution of oligo. activity of sand.

140. OLIGODYNAMIC WATER STERILIZATION BY KATADYN-SILVER (in German), Georg A. Krause, *Ges. Ing.*, 52:500 (1929). Re me of material presented in Krause's pamphlet, "New Means of Sterilization," q. v. supra.

141. THE STERILIZATION OF WATER WITH METAL WIRE (in French), Georges Lakhovsky, *Compt. Rend. Acad. Sci.*, 188:1069 (1929). Lakhovsky used metal spirals, and reduced *B. coli* 1,128,000/cc to zero in 24 hours. Believed in existence of intracellular electrical oscillation of very high frequency which can be altered by contact with mass of metal. He concluded that bactericide by metal is purely physical and caused by altering of nuclear oscillation frequency.

142. ON THE PHENOMENON OF OLIGODYNAMIC ACTION: INHIBITION BY SALT (in German), N. Leitner, *Ztbl. f. Bakt.*, 112:368 (1929). Was concerned with influence of electrolytes on oligo. action of metals. Tested bacterial action of Cu-activated water on *B. coli* suspensions as affected by various concentrations of NaCl in liquid. Bacterial counts were made in agar plates after 2 days' incubation. They observed that count at first increased rapidly with increasing dilution of NaCl down to M/8; decreased rapidly with further dilution down to M/1024; and thereafter the count

decreased gradually. Results demonstrated that oligo. action was inhibited slightly by very low and very high concentrations of NaCl, and that medium concentrations, in range M/4 to M/500, were definitely retarding of oligo. action. Strongly oligo. active water was much less inhibited by NaCl than was weaker active water. Effect of CaCl_2 as electrolyte differed in one respect from that of NaCl: addition of small amounts of CaCl_2 (M/32768 to M/8192) increased bactericide of weaker oligo.-activated water; same was observed for KCl. Bacterial concentrations ranging from 400,000 to 2 million/cc evidenced no variation in bactericidal action. Results were too irregular to permit his formulating any definite conclusion.

143. OLIGODYNAMY -- A METAL ION ACTION (in German), N. Leitner, Klin. Wochs., 54:1952 (1929). Tested effects of Ag-activated water and of AgCl solution with equal amounts of Ag ions, on *B. coli* of 100,000/cc contacted for 15 hours, mixed in agar, plated, and incubated from 36 to 48 hours. Both gave equal bactericide. This indicated that oligo. action depended greatly on metal ions concentration. Observed that oligo. action could be inhibited by presence of insoluble substances such as graphite and coke, by organic material such as filter paper, cotton, and wool, and other organics such as gum, dextrin, and albumin, -- most of which could be characterized as adsorbents and which could remove metal ions from water before they could act on bacteria. Inhibition by salts was sometimes positive, sometimes negative. Believed that in Ag-activated water, Ag was present as free metal ions, and not as colloidal Ag, or as Ag compounds. Bright Ag surfaces were rendered inactive by fouling with H_2S to form Ag_2S on surface.

144. THE POSSIBILITY OF INTERNAL DISINFECTION (in German), J. Markwalder, Schw. Med. Wochs., 59:503 (1929). Reported treatment by drinking Ag-activated water, alleviated suffering of patient with some unknown tropical disease.

145. DISINFECTION OF WATER WITH SILVER SALTS AS WELL AS WITH KATADYN SILVER (in German), W. Olszewski, Vom. Wasser, 3:91 (1929). Olszewski worked with *B. coli* and found CuSO_4 somewhat more bactericidal than CuCl_2 but doses too large for practical application. Bactericidal dose of Ag_2SO_4 for 10,600 *B. coli*/cc in 18 hours contained 0.17 ppm Ag ions; was found to be better bactericide than AgNO_3 . Traces of Pt increased bactericide. Very long contact time was required to kill spores. Dirty water decreased oligo. activity. Examination of performance of Ag-sand filter installed at bathing pool in Dresden showed for first time through filter: bacteria count in gelatin reduced from 60,900 to 4980/cc, in agar from 1670 to 40, and *B. coli* one in 50 cc. The fifth time through (recirculation) showed gelatin count 736, agar 18, and no coli in

50 cc. Recommended contact time in storage reservoir after Ag-sand filtration.

146. APPLICATION OF KATADYN TO WATER STERILIZATION (in German), C. H. Schweizer, Mitt. Geb. Lebmtl., 20:303 (1929). Claimed to verify Krause's findings that Katadyn will kill pathogens and *B. coli*, but not harmless air and water bacteria. He believed that bacteria vary in sensitivity at different times.

147. THE ROLE OF OXYGEN IN OLIGODYNAMIC ACTION OF METAL (in German), K. Suple, Klin. Wochs., 8:1899 (1929). Suple worked with *D. pneumo. Friedlander* which can grow aerobically or anaerobically. He demonstrated that presence of O_2 was not necessary for oligo. bactericide of $AgNO_3$. However, with Kollargol, bacteria were 500 times resistant without O_2 than with it. Colloidal Ag required O_2 for formation of Ag compounds which could subsequently provide free Ag ions. Ag salts could produce such ions without mediation of O_2 . These gave further support to theory that oligo. action is purely chemical and depends upon metal ions.

148. THE POISONOUS ACTION OF SOME METALS AND ALLOYS ON BACTERIA (in German), Gustav Tamman, Forsch. u. Forts., 5:257 (1929). Reviewed previous investigations. Tamman demonstrated that 5 gamma of Cu-ions/l was bacteriocidal for 5 kinds of bacteria, but that *B. coli* com. required 50 gamma. Smaller doses of Ag were required -- from 0.01 to 10.0 gamma/liter. Found that during 1 month some samples from one strain of *B. coli* com. became more sensitive to Ag, and other samples less sensitive. He found no sterile zones in plates from Au, Pt, Zn, Mn, Al, and Fe.

149. TOXICITY OF METALS AND ALLOYS ON BACTERIA (in English), G. Tamman, Inst. Met. J., 42:693 (1929). Abstract of his paper in Forsch. u. Forts., 5:257 (1929), q. v. supra.

150. THE SIGNIFICANCE OF KATADYN DEVELOPMENT FOR MILK SANITATION (in German), Trendtl, Suddeu. Molk., 50:497 (1929). Reviewed development of Katadyn by Krause. No data given on any installations for milk sanitation.

151. ON THE OLIGODYNAMIC ACTION OF SOME METALS (in German), H. Turkheim, Ztbl. gesam. Hyg., 19:712 (1929). Performed routine tests for determining oligo. action of Cd, Ag, Cu, Hg, Au, brass, and Ag-Cu alloy. Also investigated sensitivity of Staph., Strept., and *B. acido lactis.*; found Staph. most resistant.

152. THE NEUTRALIZATION OF OLIGODYNAMIC ACTIVITY OF COPPER BY ELECTROLYTE SOLUTIONS (in French), P. L. Violle and A. Giberton, Compt. Rend. Soc. Biol., 100:190 (1929). Investigated effect of

electrolytes in M/200 solutions on toxic action of Cu-activated water against fish. Salts with Cl anion gave no inhibition at any pH from 6.2 to 8.0; SO₄ anion inhibited only at pH 8.0; PO₄ anion was always inhibitive, increasing with increasing pH; inhibition by anions therefore varied with their valence. Salts with monovalent cations Ca and K were non-inhibiting. Among the bivalent cations, Mg and Sr did not inhibit, but Ca showed considerable and constant inhibition at pH 6.2.

153. THE OLIGODYNAMIC ACTION OF SILVER (in German), Paul Wernicke and Ferdinand Modern, *Biochem. Zts.*, 214:187 (1929). Wernicke and Modern observed that water could be activated by Cu only in presence of O₂, CO₂, or H₂SO₄, and same for Ag. These conditions favored dissolution of metals. Were able to indicate presence of 10 gamma Ag ions per liter of Ag-activated water. Presence of O₂ made no difference in bactericide of Ag or Cu already in solution. Therefore they assumed that bactericide occurs through direct action of metal ions and not by direct oxidation of bacteria.

154. BACTERIOLOGICAL CHEMISTRY OF THE HEAVY METALS (in English), E. A. Copper and S. D. Nichols, *J. Soc. Chem. Ind.*, 49:386 (1930). Cooper and Nichols found Cd compounds to be actively germicidal, more so than Pb salts, but less than Hg and Ag salts.

155. ON THE OLIGODYNAMY OF ELEMENTS ON MYCOBACTERIA (in German), R. Hamäläinen, *Soc. Med. Fen. Duo. Acta.*, Vol. 13, No. 5 (1930-31). Tested 42 Ag compounds on *Staph. aureus*, and determined their relative oligo. bactericidal powers by comparing diameters of their sterile zones in inoculated agar plates. Hamäläinen concluded that oligo. does not depend upon solubility but only effect of the metal ions.

156. OLIGODYNAMY OF METAL SALT SOLUTIONS (in German), S. Hoess, *Helv. Chim. Acta.*, 13:153 (1930). Reviewed work of previous investigators. Investigated oligodynamic action of various metal salts solutions on *B. coli*. Made careful attempts to maintain all test conditions equal and constant. Used aq. bidest. in vitro for all test liquids; deactivated all glassware by concentrated HNO₃. *B. coli* inoculations were from 2 strains in 3-day agar cultures, and bacterial concentrations averaged 150,000 to 200,000/cc, varying with age of culture. Oligodynamic waters were prepared by filtering solutions of various concentrations of various metal salts after 24-hour contact. Bacterial test samples were plated after contact with oligo. water for 6, 24, and 48 hours. The plates were incubated at 37 C for 120 hours. Bactericide was indicated by sterility of plate and clarity of added

Eijkmann liquid. Of salts of Ca, Co, Mn, K, Ni, Fe, Zn, Al, Sn, Pb, Bi, Cd, and Sr, some were active on *B. coli* only in high concentrations, some were entirely inactive. Cu was bactericidal at 63 gamma/l; and Ag at 1 gamma/l.

157. THE INFLUENCE OF ELECTROLYTES ON BACTERICIDE OF COPPER AND SILVER SALTS (in German), N. Leitner, Biochem. Zts., 221:42 (1930). Worked with *B. coli* suspensions of 24-hour bouillon culture, carefully centrifuged and washed for removal of all traces of albumins and electrolytes of nutrient media. Cu or Ag salts solutions in aq. bidest. were inoculated with washed bacteria, then dosed with various quantities of electrolytes. Innumerable runs showed that aq. bidest. was not bactericidal. For neutral and weakly acid salts, such as NaCl, KCl, NH_4Cl , CaCl_2 , K_2SO_4 , and MgSO_4 increasing their concentrations in Cu-oligo. water inhibited its bactericide, beginning with added salt concentrations between M/1024 and M/256, and reaching maximum inhibition at M/4 to M/16. Bactericide was inhibited maximum of 50 to 70 percent. For $\text{K}_2\text{C}_2\text{O}_4$, $\text{K}_3\text{C}_6\text{H}_5\text{O}_7$, and $(\text{NH}_4)_2\text{C}_2\text{O}_4$ results were irregular; *B. coli* thrived 8 hours in pot-citrate solution. Inhibitions to bactericide of Cu-oligo. water began at concentrations of M/51,200 to M/64,000; bactericide was inhibited as much as 90 to 100 percent. Alkaline reacting salts, such as K_2CO_3 , Na_3PO_4 , sod-acetate, and pot-acetate gave no inhibition of bactericide. Acetate solution buffered pH 4.0 gave complete inhibition of bactericide by oligo. Ag salt solutions; as pH increased to 7.0 inhibition decreased; above pH 7.0 there was no inhibition. He concluded that some salts hinder oligo. bactericide by forming metal complex salts, thereby reducing number of free metal ions effective for bacterial action. Other salts, such as NaCl, CaCl_2 , and MgSO_4 , do not change metal ion concentration in substrate but lower negative charge on bacteria, reducing their power to adsorb metal ions, resulting in decreased bactericide. Alkalis increase bactericide of oligo. metals by increasing negative charge on bacteria, promoting their adsorption of metal ions.

158. ON OLIGODYNAMY (in German), J. A. Murto, Soc. Med. Fen. Duo. Acta., Vol. 13, No. 2 (1930). Indicated previous investigators were unanimous on oligo. of Ag and Cu but disagreed on activity of Au, Pb, and Hg, both of metals and their salts. Bail ascribed such variations in results to variation in purity of test metals. Murto believed that investigators were not all talking about same things. Believed that investigation techniques were of great importance. Pointed out that even should all investigators use same type of bacteria, results would not be unanimous because of sensitivity differences of individual bacteria. (The following observations and conclusions by Murto were not supported by test data; it can only be inferred from context that they are

result of actual test observations carried on by him.) Following bacteria were sensitive to oligo. action in descending order: Mycobacteria, corynebacteria, Vibrios, Spirillaceae, and proteus. Certain bacilli were extremely resistant; pyocy. much less than fluor.; typhi. and coli less than paraty. Various strains of these species showed differences in sensitivity. Dampness of culture increased resistances of Strept. and Staph. Resistance increased with age of culture. Early formation of zoogloea increased resistance of bacteria. Various metals worked with varying oligo. intensities on various bacteria. No one metal was bactericidal to all bacteria. Made quantitative determinations of oligo. strength of metals by measuring size of sterile zone produced by each in infected nutrient plates. Professed that oligo. activity of various metals could be classed according to their position in periodic system of chemical elements. All members of any such group had approximately equal oligo. characteristics, and these general characteristics varied one way or another from one group to next. Among these he characterized Co, Rh, Ir group as oligo. active; Ni, Pd, Pt, inactive; Cu, Ag, Au, group weak; Zn, Cd, Hg group more active; As, Sb, Bi group strongly active. Observed some metals stimulated growth of some bacteria. He professed to be able to forecast oligo. character of any metal without testing it, merely by comparing with known action of some metal in same periodic system group. He then concluded that each metal has its own action on various bacteria, and therefore cannot be generalized. No one metal was observed to have outstanding oligo. inactivation or activation properties. NaCl in agar did not effect oligo. of Hg, Cd, and Sb, but inhibited completely slight oligo. of Al and Sn. NaNO_3 did not effect oligo. of Ag and Sb, lowered that of Cd, Sn, and Te. Na_2SO_4 had no effect on Sb, but lowered oligo. of all other metals. Believed that oligo. bactericidal action occurred because of neutralization of positive metal ions by bacteria. Did not feel that oligo. depended upon existence of metal salts on metal surfaces.

159. CRITICISM OF THE MEASUREMENT OF SILVER IONS IN SOLUTIONS OF COLLOIDAL SILVER (in German), K. von Neergaard, Arch. Exper. Pathol., 147:81 (1930). In measurement of H ions it had been assumed that disperse systems are homogeneous solutions, and that such measurements actually indicate number of free H ions. For example, 15 times greater H ion concentration was found in 1 percent clay suspension than in the dispersion medium. Around clay particle as nucleus is formed H ion shell which now acts upon electrodes of meter. Concentration of free ions is not measured thus, but only their average mobility. He demonstrated previously that bactericidal efficiency of AgNO_3 solution is not to be evaluated by its concentration of Ag salt, but that it rests primarily upon its relation to amount of bacterial surface present

in liquid and its adsorptive power. This means that a heavy-metal ion cloud forms around bacterium. It had been long known that upon dilution of Ag colloidal solutions, Ag ion concentrations showed no singular decrease. It is proper to assume that greater freedom of movement of Ag ion shells act upon electrodes, thereby indicating spurious increase in free ions.

160. CHLOR-SILVER AND CHLOR-COPPER IN TREATMENT OF SWIMMING POOLS (in German), Wo. Olszewski, Ges. Ing. 53:738 (1930). Proposed use of chlorine in conjunction with Ag for swimming pool sterilization. Chlorine is dosed sufficiently to make water coming into pool almost sterile, while Ag ions provide residual effect. No residual chlorine appears in pool discharge. Chlorine solution was run through bed of Ag shavings; parallel stream flowed through bed of Cu shavings to enhance metal ion supply. For total metal ion dose of 30 to 50 gamma/l, $3/4$ was Cu ion and $1/4$ was Ag ion. Tests showed required low initial Cl_2 dose in supply with good bactericidal performance (no test data given).

161. THE NEW CHLOR-SILVER STERILIZATION TREATMENT (in German), Wo. Olszewski, Pharm. Ztrh. f. Deu., 71:161 (1930). Dresden Guntzbad installed Cl_2 -Cu-Ag sterilization system, produced by Firma Chlorator G.m.b.H., Berlin Sl4, in September 1929. Where previously 60 to 90 g Cl_2 per hour was used for disinfection of 500 cu meter pool they now used $1/3$ of Cl_2 . This eliminated all Cl_2 odors and tastes in the pool. The use of Cu economized use of Ag. The results were more successful than those obtained from use of chloramines. Another installation is proposed for Dresden Volksbad N.W.

162. CHLOR-COPPER AND CHLOR-SILVER IN THE TREATMENT OF WATER AND WASTE (in German), G. Ornstein and R. Kroke, Ges. Ing., 53:153 (1930). Gave manufacturers' views on applications of Cl_2 -Cu-Ag equipment, and complete details with sketches of apparatus. Installation was made at cellulose plant Tellner and Co., Ziegenhals, for elimination of algae and fungi in raw process water. Previously required 20 g Cl_2 /cub. met. or 100 g $CuSO_4$. They obtained sufficient treatment by new apparatus using an average of 2.5 g Cl_2 and 0.18 g Cu/cub. meter. Another installation was made at paper mill Herzberg using 0.1 to 0.45 g Cl_2 /cub. met. and 0.004 g Cu. Trial installation was made at Jungfernheide pumping station of Berlin Water Works handling polluted River Spree water. First 3 tests showed residual of 0.02 ppm Cl_2 to be insufficient for disinfection. Next 3 tests indicated that 0.3 ppm Cl_2 residual did not permit effective action of added 3 gamma Ag/l. But next test showed sufficient reduction in bacterial count with 8 gamma Ag/l and 15-minute contact period. However, chlorination alone produced equally good results. Filtration

before sterilization improved disinfection greatly. Another run with 15 gamma Ag/l plus Cl_2 showed definite bactericide. Further treatment with 16 gamma Ag plus 0.5 ppm Cl_2 residual, with filtration, produced almost sterile water in 5 minutes.

163. BIOLOGIC ACTION OF METALS ACTIVATED BY ULTRA-VIOLET RAYS (in German), O. Reid, Wien. Klin. Wochs., 43:394 (1930). For tests Reid used commercial bakers' yeast suspension in 1 percent solution of tech. dextrose in tap water in petri dish. In lid was pasted leaf of Al, or Sn. After incubation at 20 C and at 27 to 29 C for 24 hours found plus or minus 10 percent variation in growths. However, growth seemed to increase during first 7 days, then became inhibited compared to controls. Metal leaves were then exposed to light of mercury vapor quartz lamp at 15 cm for 4 minutes. Again on yeast, with non-irradiated metals as controls, irradiated Sn showed great stimulation of growth during first 7 days, then of equal influence thereafter. Irradiated Al showed stimulation only during first $2\frac{1}{2}$ days, then inhibition to 7th day. Assumed that these indicated phenomenon of telergy for both irradiated and non-irradiated metals. Al and Sn leaves were placed in bottom of petri dishes, covered with oil, then irradiated with ultra-violet light. Leaves, after removal, proved more stimulating to growth of yeast cultures than did oil.

164. COMPARISON OF GERMICIDAL POWER OF COLLOIDAL METALLIC SILVER AND OF IONIC SILVER ON E. TYPHI (in English), Karam Samaan, Quart. J. & Yearbk. Pharm., 3:21 (1930). Worked with B. typhi. Fresh from patient, in agar culture, suspended in solution of Ag colloid or AgNO_3 in aq. dest. in vitro. Observed colloidal Ag to be less effective than ionic Ag in AgNO_3 . Found that B. typhi. could live in sterile aq. dest. at least 30 days at 20 to 30 C. All glassware used was cleaned.

165. THE CHEMISTRY OF DISINFECTION (in English), W. D. Bancroft and G. H. Richter, J. Physical Chem., 35:511 (1931). Explained action of disinfectants thus: Disinfectant enters cell and is adsorbed by colloids after displacing material previously adsorbed. This displacement increases effective concentration of previous substance in substrate, accelerating its diffusion into cell and resulting in stimulation of growth by toxic agents observed by all workers. Accumulation of disinfectant in cell continues until its action combined with cellular electrolytes results in coagulation of colloids of protoplasm. This change of cellular substance hinders diffusion of nutrients from medium into cell, and effect is one of narcosis, or bacteriostasis. Same effect is produced through direct blocking of enzyme surfaces by adsorbed disinfectant. Indirect coagulation can result from interference by substance with action of some respiratory enzyme,

and accumulation of incompletely oxidized substances in cell can produce coagulation of cell colloids, then narcosis. Removal of coagulating agents brings about reversal or peptization of colloid with return of cell to normal and loss of toxication symptoms. However, if colloid substances are so drastically changed as to prevent peptization, or if agent is irreversibly adsorbed then cell is considerably damaged. According to the Schulz-Arndt law substance at low concentrations can stimulate growth of bacteria; inhibit growth or produce narcosis or bacteriostasis at higher concentrations; and at still higher concentrations, can produce irreversible toxic action. Cited Heilbrunn (The Colloidal Chemistry of Proteins, 1928) that low concentrations of HgCl_2 produced coagulation, or at least great increase in viscosity of colloids in various types of protozoa. Bancroft & Richter demonstrated that yeast culture treated with 10^{-3} solution of HgCl_2 for short time showed complete coagulation under ultramicroscope. Treatment with chloroform, however, produced narcosis, the coagulation could be reversed merely by washing with fresh medium. In most cases where irreversible coagulation is final, there is preliminary stage where reversibility is possible. Substances that produce reversible coagulations also produce irreversible coagulation if allowed to act in higher concentrations. It is difficult to draw sharp line between narcotic and toxic drugs; colloidal properties of protoplasm involved will determine course of action of agent. Evidence based on study of representative heavy metals, such as Hg compounds, of chloroform, phenols, etc., showed that they all act in same manner, i.e., by coagulation, a physical action. The testing of disinfectants should be studied from point of view of reversibility of coagulation produced rather than determination of growth on relatively inert media, after exposure.

166. STERILIZATION OF WATER BY METALS (in French), F. Dienert and P. Etrillard, Compt. Rend. Acad. Sci., 192:185 (1931). Immersed metal spirals in vessels of water infected with B. coli. Ag and Zn decreased B. coli from 800 down to 150/cc during first 3 days, thereafter count increased to 1100/cc for Zn, and enormously for Ag. Seine River water with initial 400 to 600 B. coli/cc passed through bed of Ag-covered sand for several minutes, resulted in considerable reduction. With contact of $\frac{1}{2}$ hour, B. coli disappeared rapidly and water had absorbed 3 gamma Ag/l. When Ag-activated water was filtered through ordinary sand, activity disappeared but filter sand became active. Activity increased with temperatures; B. coli died in 1 hour at 37 C, but in 3 hours at 20 C.

167. ON A SIMPLE STANDARD METHOD FOR INVESTIGATIONS OF OLIGODYNAMICS OF SILVER (in German), H. Gottschalk, Ztbl. f. Bakt.,

122:400 (1931). Proposed as standard methods, use of 5 mark silver coin (German) cleaned, gave details of cleaning, preparing bacteria suspension, contacting with metal, and subsequent proof of sterility. Stressed fact that aq. bidest. in Jena glass was oligo. active; removed oligo. traces by filtering through Berkefeld filter candle, which became too oligo. contaminated after filtering 150 l. His investigations showed regularity of sensitivity of *B. coli* to Ag, whether fresh or cultures years old. *B. typhi* and dysent. were more sensitive. Results for *B. paraty.* were non-conclusive.

168. ON THE THEORY OF OLIGODYNAMY OF ELEMENTS OF MYCOBACTERIA (in German), Váinó Horelli, Soc. Med. Fen. Duo. Acta., Vol. 13, No. 5 (1930-31). Horelli first presented complete historical review in form of abstracts of some 100 papers published since 1889. Horelli's investigations dealt with 18 different mycobacteria species and 5 various tuberculosis bacilli, using 44 different metals. Observed all precautions to assure constancy of test conditions and to avoid sources of error. He used up to 4 different metals on single agar plate. All qualitative determinations were based on measurements of sterile zones produced, and examination of other zones in plates. He arrived at same conclusions as Murto had, viz., oligo. actions of metals are related to their positions in periodic tables. Strongest bactericidal to mycobacteria were As, Sb, Tl; strong bactericides were Cd, Hg, Zn, and Ge; weak but definite bactericides were Co, Rd, Ir, Cu, Ag, Bi, In, Te; growth promoting were Di, W, U, Mn, Ni, Er, Y, Fe, and Mo; indifferent were Mg, C, Si, Zr, Cr, Pd, and Pt.

169. ON THE COMBINATION OF FINE-PORE FILTERS WITH KATADYN (in German), F. Konrich, GWF, 74:329 (1931). Described an arrangement of Berkefeld filter candles filled inside with Ag-covered sand of 0.5 mm effective size; and Seitz filter press elements containing such sand. During filtration Ag was imparted to filtrate, thereby sterilizing it. During resting periods Ag was imparted to filter elements keeping them sterile.

170. OLIGODYNAMIC ACTION OF METALS ON BACTERIA (in Italian), G. La Cava, An. d'ig., 41:612 (1931). Investigated essential cause of oligo. action. Made tests on infected agar plates using non-treated Ag coins, coins contacted with high frequency electric current, and coins immersed for short time in H_2O_2 solution. Sizes of sterile zones produced increased in same order. He believed that Ag decomposed H_2O_2 by catalysis, providing free O_2 on surface of Ag, which combined to form Ag_2O . High frequency electric current produced ozone from air surrounding Ag coin, ozone collected on Ag, and then formed Ag_2O on surface. Ag_2O in both above cases went into colloidal solution in medium, and by

its ionic action penetrated to interior of bacteria, thereby killing them or making them static. He concluded that oligo. action of metal depends upon colloidal solubility of metal in ambient medium; and its bactericide upon its ability to penetrate into bacterial protoplasm.

171. LIMITATIONS OF PHENOL COEFFICIENT TESTS IN DETERMINING GERMICIDAL ACTIVITIES (in English), G. F. Leonard, J. Infec. Dis., 48:358 (1931). After regular phenol test showed 1:800 solution of colloidal Ag compound germicidal on *Staph. aureus* in 15 minutes, Leonard made a subsequent test by transferring a loop-full of previous test into fresh medium. Transfer showed continued bacterial growth. This indicated to him that action of Ag was bacteriostatic. He concluded that most mild and strong Ag protein preparations have high bacteriostatic action. "Use of transfer test has clearly demonstrated limitations of phenol-coefficient test in determining germicide of silver preparations."

172. INVESTIGATIONS ON THE ACTION OF IRRADIATED METALS ON BACTERIA (in German), O. Reid, Ztbl. f. Bakt., 121:267 (1931). Investigated effects of irradiated (ultra-violet rays) and non-irradiated Sn and Al leaves on *Enteroco.* in dextrose bouillon. Both metals were in contact with culture, or fixed at some distance therefrom. Test plates were incubated 8 to 48 hours at 37 to 40 C. Results were determined by noting changes in acid or alkaline products, formation of coloring matter, and toxins. He observed a telergic action of irradiated and non-irradiated metals. However, some difference in action, both telergic and in contact by irradiated metals was noted. Effects of all modes of application varied with pH of medium.

173. INVESTIGATIONS ON THE OLIGODYNAMIC ACTION OF COPPER (in German), W. Schwartz and H. Steinhart, Arch. Mikrob., 2:261 (1931). Reviewed work of previous investigators. Investigated effect of Cu on *Asperg. niger*, using $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ as source of oligo. metal. Developed colorimetric method for indicating presence of Cu down to 4 gamma/l, and with this was able to demonstrate existence of oligo. pollution in aq. bidest. in vitro. Also adopted measures to nullify oligo. adsorption and desorption of glass for eliminating one source of errors. Effects of varying doses of Cu were observed on life processes of *Asperg. niger*. No growth was observed with 0.05 percent Cu after 30 days' incubation. With 0.01 percent Cu, 2 out of 12 flasks showed small mycel islands, with hardly measurable increase in growth. With 0.001 percent Cu (10 ppm) regular growth began.

174. THE STERILIZATION OF WATER BY CATADYN SILVER (in English), E. V. Suckling, Water and W. Eng., 33:625 (1931). Reviewed

work of previous investigators. Remarkd considerably on Krause's "Katadyn" method and criticized his bacteriological tests, maintaining that he should have regarded as criterion *B. coli* in 100 cc rather than in 1 cc. Suckling investigated filter using sand covered with catadyn silver. Used *B. coli* in McConkey's bile-salt-lactose-litmus broth, and neutral-red-bile-salt lactose agar. Death was considered to have occurred when bacteria were no longer able to multiply in most favorable ambient conditions. Believed that Krause and some other experimenters had incorrectly based their conclusions on findings from use of solid media only, whereas very often liquid media would have shown continued viability. Suckling filtered through the Ag-sand aq. dest. containing *B. coli* in numbers far exceeding those likely to be met in practice. Produced relative sterility within few hours after filtration. Same results were obtained with suspensions in tap water. Found no resistant strains of *B. coli*. Found *B. typh.*, paraty., dysent., and *Vib. cholera* were destroyed as readily as *B. coli*. Most resistant were spore formers, "but there is no evidence that these are ever cause of water-borne diseases." Observed catadyn to be more efficient than Cl_2 for disinfection of aerobic sporulating bacilli, *B. mycoides*, and *B. subt.*

175. SIGNIFICANCE OF GRAM POSITIVE OR NEGATIVE OF BACTERIA IN DISTILLED WATER, AND THE ACTION OF MINIMAL QUANTITIES OF HEAVY METAL SALTS (in German), Kurt Tauchert, *Zts. Desinf. u. Gesw.*, 23:213 (1931). Made careful investigations of oligo-effects of $CuSO_4$, $FeCl_3$, $CeCl_3$, $La(NO_3)_3$, $AuCl_3$, $PtCl_4$, $Th(NO_3)_4$, $AgCl$, and $SnCl_2$, on various bacteria. Bacteria cultures suspended in aq. bidest. in Jena glass, centrifuged to ensure complete removal of nutrient medium from suspension, and 1 drop was inoculated in test tubes of various salt solutions in varying concentrations. Initial bacterial concentration in tubes ranged 100,000 to 500,000 per cc. These were then maintained at temperatures of 18 to 25 C and at 3 to 7 C, and regularly at intervals of $\frac{1}{2}$, 1, $1\frac{1}{2}$, 3, and 18 hours, bacterial counts were made in samples from each test tube after further incubation in liquid agar slants, and on solidified slants. Comparing with suitable controls he thus kept close and constant check of progress of growth inhibition or bactericide. Tests were run in 2 or 3 simultaneous series to iron out irregularities. His examinations showed: Gram negative *B. prodig.* much less resistant to $CeCl_3$ than gram positive *Staph. aureus*. It was bactericidal on *B. prodig.* in concentrations down to M/40,000 at 20 C for 18 hours contact. With $AgCl$ 590,000/cc of gram positive *Staph. alba* were killed in $\frac{1}{2}$ hour by M/400,000 at 5 C, and by M/6,400,000 in 20 hours. The gram negative *B. pyocy.* were slightly more resistant to $AgCl$: 660,000/cc were killed in $1\frac{1}{2}$ hours by M/400,000, and in 20 hours by M/3,200,000. The gram positive *Sarcinae* were much more resistant to $AgCl$ than either of

the foregoing: 27,400/cc were killed in 20 hours by M/80,000. Analogous results were obtained by CuSO_4 at 5 C. Was unable to establish any regular relationship between valence of metal cation and resulting oligodynamic action.

176. THE ACCELERATION OF THE DEHYDROGENATION OF MERCAPTO-COMPOUNDS BY METALS: AN ATTEMPT TO EXPLAIN THE OLIGODYNAMIC ACTION OF METALS (in German), Th. Bersin, Biochem. Zts., 245:461 (1932). Bersin recalled previous knowledge of fact that intracellular Fe and Cu and various auto "oxydable SH compounds are important catalytic elements for life processes. Any change in optimum concentration of these will cause disturbances in life of organism. Bersin undertook to show that oligo. action of metal ions causes irreversible oxidative destruction of thiol-disulfide system so important for enzymes of intracellular metabolism. He investigated action of solutions of pure metals on dehydration of thioglycolacidanelide, and found oxidation activity was accelerated by metals in following descending order: As, Cu, Sb, Zn, Cd, Ag, Fe, and Ni. From this he could conclude that in cells, in presence of O_2 and in alkaline milieu, metals could accelerate dehydration of SH groups to SS groups, in same order of oligo. activity as observed in his experiments. He believed that equilibrium of living thioldisulfide system is disturbed by H-donor of higher reduction potential, so that SH-components form complex compounds with oligo. active metal and which dehydrates much more rapidly to disulfide.

177. CATADYN PROCESS FOR WATER STERILIZATION (in English), Bigger and Griffiths, Brit. Med. J., No. 3749 (1932). A report of their paper read before the Royal Society of Medicine, dealing with experimental pilot model, which they said gave "good results." No experimental data were included.

178. COMPARATIVE STUDIES OF THE NATURAL AND ACQUIRED RESISTANCE OF CERTAIN STRAINS OF E. COLI TO BACTERIOSTATIC AND GERMICIDAL EFFECTS OF CATIONS (in English), Earle K. Borman, J. Bact., 23:315 (1932). Borman worked with 2 strains of E. coli, one freshly isolated from contaminated water supply, and other from stock laboratory culture and sought to determine critical bacteriostatic and germicidal doses of salts of various metals. For bacteriostasis, treated subcultures were incubated 48 hours at 37 C then examined for growth. Tube with highest salt concentration showing growth was streaked on endo-medium for confirmation. For testing germicidal efficiency, 24-hour 37 C cultures in Doff's medium were centrifuged, sedimented, and bacteria were washed three times in sterile aq. dest. and centrifuged. Inoculations of the test suspension were then made in tubes of various salt solutions and exposed to their action for 6 hours at 37 C.

Subcultures in nutrient broth were then incubated 48 hours at 37 C and examined for growth. Test data were presented representing the results. For *E. coli* isolated from polluted water he found following molal concentrations of metal ions to give bacteriostasis and germicide: Hg-M/ 10^6 and M/ $2 \cdot 10^7$; Cu-M/ 10^3 and M/ $2 \cdot 10^3$; Fe-M/ 10^3 and M/ $2 \cdot 10^3$.

179. EVALUATION OF OLIGODYNAMIC SILVER-ACTIVATED WATERS IN BIOLOGICAL INVESTIGATIONS (in German), Franz Eichbaum, *Ztbl. f. Bakt.*, 126:128 (1932). Suggested method for determination of oligo. activity of Ag-activated water, by comparing it with "standard" of known oligo. strength. Standard would be prepared by contacting 100 cc aq. bidest. with 100 mg Ag₂O for 1/2 hour at room temperature in dark, centrifuge 10 min, pipette supernatant into glass flask, dilute 1 cc with 49 cc of aq. bidest. This could kill *B. coli* 3000 to 5000/cc in 2 hours at 37 C with dilution of 1:2 containing 240 gamma Ag/l.

180. ON THE MODIFICATION OF OLIGODYNAMIC ACTION (in German), H. Gottschalk, *Ztbl. f. Bakt.*, 123:468 (1932). Investigated effects of varying test conditions on oligo. action of Ag-activated water on *B. coli*. One day agar-slant cultures with sterile aq. bidest. in vitro, suspended to give bacterial dilutions about 1500/cc. Count was made from streaks on endo-agar plates. His tests showed following: (1) Effect of bacterial concentration: 1000-fold increase in initial bacterial count from 980/cc to 980,000/cc required 4-fold increase in contact time for bactericide from 2 hours to 8 hours, all other conditions remaining constant. (2) Effect of ratio of Ag surface to water volume: decreasing Ag surface to 1/32 of original value with water volume and other factors constant, decreased bactericide in greater proportion than did increase of bacterial concentration; contact time was increased about 8-fold. (3) Effect of salt content in water: increased electrolyte content decreased bactericide, thus, contact time of 2 hours for N/5000 salts increased to 4 hours for N/650. (4) Effect of temperature variation: little difference was observed between 37 C and 20 C, but for 0 C more than 6 hours' contact was required as against 2 hours at 20 C. Lower temperatures also decreased solubility of Ag in water. (5) Effect of O₂: obtained only contradictory results.

181. ON THE TOXICITY OF HEAVY METAL SALTS ON MICROORGANISMS (in German), M. Gutstein, *Ztbl. f. Bakt.*, 124:572 (1932). Investigation of relation of lipoid-solubility of heavy metals and their bactericide. Added 0.5 cc of 2 percent plant phosphatide in water to a series of tubes, each with 1 cc of various metal salt solutions in various dilutions, and observed precipitation at intervals. Facility of precipitation of phosphatide was found to

decrease in following order: Hg, Ag, Zn, Cu, Ba, and Ca. Since, as he believed, bactericidal power of heavy metal was conditioned by its affinity to lipid substance in cell membranes, he concluded that oligo. bactericide of metals varied in above order.

182. A CATALYTIC INDICATOR FOR HIGHLY DILUTED SILVER SOLUTIONS (in German), Frederich L. Hahn, Ber. deuts. chem. Ges., 65:840 (1932). Developed a redox reaction for oligo. Ag indication. Gradual reduction of HgCl_2 by phenyl-hydrazin in acetic acid solution is accelerated by presence of Ag. Effect of as little Ag as 5 gamma/l. is thus discernible. By addition of hypophosphite determination could be made for as little as 1 gamma/l.

183. BACTERICIDAL POWER OF SILVER (in French), André Kling, Compt. Rend. Acad. Sci., 194:1402 (1932). Found no variation of oligo. action of Ag for varying pH. Same activity was observed at pH 5.8 to 8.0.

184. STERILIZATION OF DRINKING WATER BY METALLIC SILVER (in French), André Kling, Acad. Med. Bul., 107:830 (1932). Reviewed previous investigations critically. Was able to make raw River Seine water bactericidal by passing through filter paper, then contacting for various periods of time with pumice powder covered with AgCl_2 , Ag-covered sands, Ag-covered bodies, etc. Spores were resistant; *B. typhi.* and *coli* were always killed with water activated only 10 to 15 minutes, and with 4 hours' contact. Bactericide of Ag-activated water was not changed by added alkali-chlorides; but weak current of H_2S deactivated water completely.

185. OLIGODYNAMIC ACTION OF METALS (in English), H. Langwell, Chem. and Ind., 51:701 (1932). Differentiated between actions of metal and that of its ions. Metals can produce toxic ions. Believed that oligo. action can inactivate extracellular enzymes, inhibiting fermentation without injury to organism.

186. INFLUENCE OF HEAVY METALS AND METAL COMPLEXES ON PROTEOLYTIC ACTION (in German), L. Michaelis and Kurt G. Stern, Stud. Rockf. Inst. Med. Res., 81:231 (1932). Worked with Cu, Hg, Zn, Mn, and Fe on enzymes. These formed metal complexes, deactivating enzymes.

187. THE OLIGODYNAMIC ACTION OF METALS, IN THEORY AND PRACTICE (in German), M. Neisser and F. Eichbaum, Erg. Hyg., 13:170 (1932). Neisser and Eichbaum presented critical review of work of previous investigators. Acknowledged validity of oligo. action of metals on biological processes. These act through formation of metal protein complexes with living substances, toxins, and enzymes, or as catalysts. The following are their conclusions

from their literature research and their work. Only Cu, Tl, and Cd, are oligo. active in their pure state. All other metals shown to be oligo. active by previous investigators could have contained other metal impurities which imparted oligo. characteristics to test metals. Strength of oligo. action of metal depends upon number of its ions set free in solution. The non-noble metals like Cu have greater electrolytic solution ability than do noble metals, such as Au and Pt, and therefore have greater ability to produce oxidation products which can dissociate to provide free metal ions that become active agent in bactericide. Oligo. character of metal is entirely independent of its position in periodic system. However, no regular rule can be established in assigning oligo. action to various metals. Theories in this regard of Murto and Horelli are not well grounded physically or biologically; their sterile zone studies provide no exact basis for quantitative determinations. Neisser and Eichbaum demonstrated error of method of determining oligo. action by placing metal in nutrient media; Mo in an agar plate inoculated with *B. coli* showed no sterile zone, yet produced extraordinary bactericide in test tubes with *B. coli* suspensions in water. Constituent salts and colloids of nutrient medium can retard or promote oligo. action. Testing of metal in nutrient medium can act only as first approximation or orientation. In using aq. dest. its inherent bactericidal power should be recognized, and should not be used as control medium. For determining comparative specificity of various bacteria to oligo. action, evaluation should be made separately for each strain. Their own investigations, following Gottschalk's "standard" methods (q.v. supra) on *B. coli* contacted $1\frac{1}{2}$ hours by various methods, and on *Staph. aureus* contacted $3\frac{1}{2}$ hours showed: inactive, Al, Ge, In, Mg, Mn, Sn, Zn, and Zr; slightly active, Co, Cr, Sb, Se, Si, Te, and W; medium active, Bi, Cd, Ce, and Ti; strong, Ag, Cu, and Tl; very strong, Mo (at times). Reviewed various methods of indicating oligo. Cu and Ag. The dissolution of oligo. metal can proceed in form of free metal ions, complex ions, or as colloid, depending upon electrolytic and organic constituents of dissolution medium. In any event, metal surface salts must be formed first which can subsequently dissociate and ionize. Ag metal washed with KCN became non-oligo. Ag metal contacted with H_2S was left with surface salts completely insoluble and non-ionizable, therefore non-oligo. After release of metal ions, they are adsorbed by bacterial surfaces, following the Freundlich adsorption isotherm. They formed no definite conclusion as to subsequent action of metal in cell.

188. BACTERICIDAL EFFECT OF SILVER (in German), M. Neisser, *Forts. d. Med.*, 50:1095 (1932). Criticized classic method of using metal placed in culture medium for investigating oligo. action. Bacteria become tolerant to Ag in such media; bactericidal doses

of Ag become reduced to bacteriostatic or growth-promoting doses. Ionic Ag can be turned into colloidal Ag compounds by reducing agents which can also be present in water, and which will retard bactericide. Was able to verify activation and deactivation of metals demonstrated by previous investigators. Also showed importance of formation of Ag salts in oligo. process. Cited Leitner who stated that after adsorption of Ag ions by bacteria there still remained $1/2$ to $1/5$ of original Ag ions in water. Stressed necessity for more careful research techniques. To establish fact of bactericide by Ag, the contact period should last $3/4$ to 3 hours. Effect of aq. dest. should be checked carefully. Recommended Gottschalk's "standard" method. Pointed out fact that oligo. pollutions were present in aq. dest. and in laboratory glassware. Adsorption by bacterial surfaces conditioned by acidity of medium. Remarked on Krause's Katadyn equipment. In Frankfurt Neisser checked performance of Electro-Katadyn installation in drinking water plant for 1 year, and controlled bactericide of plant.

189. OLIGODYNAMIC ACTION OF METALS (in French), M. Pilod and F. Codvelle, Ann. d'Hyg. Pub., 10:654 (1932). Reviewed work of previous investigators. Pilod and Codvelle made thorough investigations of all factors involved in oligo. activity of metals. Various metals-activated waters were applied to *B. coli* chosen for constant vitality, and ability to live as long as possible in aq. dest. They defined arbitrary standard unit for expressing relative oligo. action, designated as "OD," which corresponded to activity of water capable of destroying 2,000,000 *B. coli*/cc with 24 hours' contact at 37 C. Titration of various waters tested was then reported in terms of OD; thus, water that could kill 100,000 *B. coli*/cc was designated OD/20, and OD/10 for 200,000/cc. They observed strong oligo. action of Cu; 10^{-10} of $HgCl_2$ killed 200,000 *B. coli*/cc in 24 hours; but no activity was observed for Pb, Fe, and Sn. In attempting to activate tap water by coupled metals, they found that Zn increased activity of Cu alone, Sn was indifferent to Cu, and Pb hindered action of Cu. Of equal sensitivity to Cu-activated water were *Eberth.*, *B. paraty. A* and *B.*, and dysent. Shiga; slightly more resistant were *B. dysent. Flexner.*, and *Vib. cholera.* *B. pyocy.* at 50,000/cc were just as resistant as *B. coli* at 2,000,000/cc. Strept. were more resistant than *Staph. aureus* and *Enteroco.* The authors observed oligo. activity to vary directly with contact time and inversely with dilution of metal ions. They cited that according to Vignati and Schnabel (q. v. supra), bactericidal agent could be removed from affected bacteria by washing with 2 percent sodium thiosulfate or by 1 percent citrate of sodium and by this means bacteria could be revived. However, Pilod and Codvelle remarked that they were unable to verify such revivification in laboratory, and that in practice,

oligo.-treated bacteria could never encounter such revivifying substances. They were able to inactivate tetanus toxin by contacting with Cu wire for 20 days, thereby enabling guinea pig to tolerate 100 times usual toxic dose. They were able to verify previous work on activation of water by contact with metal. Were unable to activate water by metal in atmosphere of N_2 . They concluded that oligo. metals require intervention of O_2 or CO_2 for activating water. Action of colloidal Ag preparations, such as collargol in O_2 or CO_2 rests upon production of ionizable Ag-oxide. Activation of water varied directly with temperature. Found no difference in activation caused by light or darkness. Amount of activity imparted varied directly with length of contact time, slowly at first, then increased rapidly, and finally tapered off to saturation value. Presence of 0.1 percent NaCl, 0.1 percent Na_2SO_4 or 0.1 percent KI in either tap water or aq. dest. produced no effect on their activation by metal. Same indifference was observed with 0.2 percent glucose in water. Water containing 1 percent egg albumen and contacted 4 days by Cu showed no antibiotic properties on *B. coli*. They demonstrated oligo. inhibitory or nullifying effect of inert adsorbents, such as bone charcoal, kaolin, talc, filter paper, etc. Addition of 0.1 percent NaCl to water after its activation did not retard its activity. Addition of 0.1 percent serum increased bactericidal contact time to 3 hours from 2 hours for one million *B. coli*/cc. They believed germicide to be a physico-chemical action, and caused by flocculation of biocolloids in microbe. Oligo. sterilization of water is slow and requires good storage.

190. ON THE QUESTION OF DRINKING WATER STERILIZATION IN THE TROPICS (in German), Henrich Ruge, Arch. f. Schiff's u. Trop., 36:208 (1932). Suspensions of cultures of various bacteria were made in Ag-activated tap water with various concentrations of Ag and with bacterial concentrations of 500,000/cc; kept at room temperature for various contact periods, and tested for growth. With 130 gamma Ag/l, no growth was observed of *B. coli* with 8 hours' contact, *B. typhi*. at 4 hours, *B. paraty.-B* at 4 hours, and dysent.-Shiga at 1 hour. With 170 gamma Ag/l no growth of *B. coli* appeared after 2 hours, all others after 1 hour. With 200 gamma Ag/l no growth of *B. coli* and *B. typhi*. appeared after $1\frac{1}{2}$ hours, of *B. paraty.-B* after 4 hours and dysent. Shiga after 1 hour. With 300 gamma Ag/l no growth of *B. coli* appeared after 2 hours, *B. paraty.-B*. after 2 hours, all others after $1\frac{1}{2}$ hour. Jena glass flask was filled with tap water activated with 300 gamma Ag/l and stored 10 days. Flask was then emptied, rinsed repeatedly, filled with tap water, and inoculated with bacteria at 50,000/cc. *B. coli* were all dead in 48 hours, while *B. typhi*, *paraty.-B*, *proteus* and *Staph. alba*, were all dead in 24 hours. Same water was further inoculated with 500,000/cc of bacteria, and

again gave analogous results. Flasks were rinsed, again filled with tap water, and inoculated with 50,000/cc bacteria. *B. coli* and all other bacteria were dead in 72 hours. With further inoculation of 500,000/cc of bacteria, death resulted for all 120 hours later. Thus, ability of Jena glass to become oligo. activated was demonstrated.

191. THE STERILIZATION OF WATER BY CATADYN SILVER (in English), E. V. Suckling, Water and W. Eng., 34:15 (1932). Continuation of paper of 1931. Used bed of Ag-sand for treating various natural waters from river, lake, spring, shallow well, and dug well. Sterilization of these waters was retarded by their suspended matter, color, dissolved organic matter, and sulfides. With clear bright water, Ag-sand was more effective, both at pH 5.0 as well as pH 9.0, and on many types of bacteria. High filter rates followed by long storage gave better results than low filter rates and short storage. Water retained long-time residuals capable of sterilizing after-pollutions. Activated water stored in stoppered bottle for 2 years was still active. Activation was removed by ordinary sand filter, by activated carbon, or by softening with lime and sedimentation. Found action greatly retarded at 0 C.

192. HEMOLYTIC ACTION OF SILVER OCCURRING AS AN IMPURITY IN CHEMICALLY PURE NaCl (in English), E. G. Ball, Biol. Bul., 64:277 (1933). Demonstrated by experiments hemolysis caused by presence of Ag in certain brand of c.p. NaCl used for physiological saline solutions. Solution after being filtered through charcoal became non-toxic. Ash of charcoal used made non-toxic NaCl toxic when added to it. Spectrographic analysis of charcoal ash indicated presence of Ag after filtration. Thus, Ag was traced to NaCl. Subsequent investigation revealed that final step in refining of salt was carried on in Ag-lined vessels. Salt produced in porcelain vats would be non-toxic. Warned that indiscriminate use of NaCl may be cause of changes in experiments.

193. COMPARATIVE BIOLOGICAL INVESTIGATIONS ON THE EFFECTIVENESS OF SWIMMING POOL WATER TREATMENT BY STERILIZATION WITH CHLORINE-SILVER-COPPER (in German), Adolf Beck, Arch. f. Hyg., 109:177 and 189 (1933). Investigated performance of Cl-Ag-Cu sterilization apparatus newly installed at Louisa indoor pool in the city of Marburg. Disinfectant solutions added to recirculated pool water after passing through sand filter. Hypochlorite solution was dosed with either Ag, Cu, or both by running it through beds of metal shavings. Over a 2-year period, regularly checking bacteriological results monthly, Beck observed following: Of 27 examinations with Cl₂ treatment only, 4 showed bacteria counts over 400/c with maximum of 1225; 2 showed positive for *B. coli*

in 100 cc of pool discharge with 0.17 ppm residual Cl_2 . Bacteria increased through filter as much as 500 times, as did *B. coli*. With Cl_2 plus Cu treatment, obtained lowest average bacterial count in filtrate 1764/cc but no *B. coli*. With Cl_2 plus Ag, average bacterial count was 3173/cc in filtrate and *B. coli* was positive 7 times in 100 cc and 2 times in 10 cc. With Cl_2 plus Cu plus Ag, average bacterial count was 4828/cc in filtrate and *B. coli* was positive 6 times in 100 cc and 2 times in 10 cc. Concluded that Cl_2 plus Cu was more effective than other means, and also acted to reduce required Cl_2 dose.

194. THE DISINFECTION OF WATER BY THE CATADYN SYSTEM (in English), Joseph W. Bigger and Louis L. Griffiths, Irish J. Med. Sci., 85:17 (1933). Activated water with Ag-covered boluses, beads, and sand. For 15 g Ag on sand/l, water absorbed 6 gamma Ag/l. Twenty-four hour *B. coli* in broth culture was suspended in 300 cc sterile tap water in glass flasks containing Ag-sand, kept in dark for various contact periods. *B. coli* of 68/cc were killed in 2 hours, 7850/cc in 24 hours, Pathogens were killed as easily.

195. CONTRIBUTIONS TO THE STUDY OF OLIGODYNAMIC ACTION WITH PARTICULAR REGARD TO DEACTIVATION AND REACTIVATION OF SILVER (in German), Ilse Bührmann, Zts. f. Hyg. u. Infek., 115:241 (1933). Attempted to develop method for determining oligo. power of Ag-activated water, by use of bacteria motility reaction. Ag vapor produced at 825 C was forced through aq. bidest., thus activating it. Regarded this as refutation of Saxl's "Fermwirkung." Reviewed and verified previous methods of activation and inactivation of oligo. metals.

196. THE BACTERICIDAL PROPERTIES OF SILVER CHLORIDE (in Neth. Dutch), J. Dekker and C. H. Dekker, Pharm. Wkld. Ned., 70:23 (1933). Demonstrated by inoculated nutrient plates that AgCl solution exposed to light retarded bactericide.

197. DISINFECTION OF WATER WITH SOLUBLE SILVER SALTS (in Russian), S. Dmitriev, Voenno. Med. Zhur., 4:367 (1933). Attempted to supply information, heretofore scarce, on use of soluble Ag salts for sterilization of water. Dmitriev's tests revealed that as Ag content of water increased from 10 gamma/l, growth was first stimulated, then retarded, and finally a bactericidal dose was obtained. For all various river waters he tested, largest Ag dose required was about 0.1 ppm, although no actual bactericidal dose was shown in test data. The bacteria used were native to water.

198. OLIGODYNAMIC SILVER TREATMENT OF WATER (in English), J. Gibbard, Amer. J. P. H., 23:910 (1933). Investigated action of Ag-covered porcelain rings. With *B. coli* or typhi. at 1 million/cc

in tap water, contact with rings for 1 hour at 22 C did not stop bacterial growth, but 2 hours' contact showed negative. As criterion for sterilization he took failure of growth in lactose broth incubated 48 hours at 37 C. *B. coli* at 2 million/cc were sterilized in 4 hours at 37 C, but not even after 22 hours at 10 C. Concentration of bacteria affected oligo. efficiency; thus, 500,000/cc could be sterilized at room temperature in $1\frac{1}{2}$ hours, but $1\frac{1}{2}$ million/cc might take 10 hours' contact. The results of 16 tests for dependency of bactericide on temperature showed that about 4 times the contact period of 22 C was required at 8 C. There was no effect caused by pH. Bactericide in aq. dest. was quicker than in tap water. There was no evidence of revival of any organisms killed by Ag. Gibbard's work with AgNO_3 showed *B. coli* at more than 1,250,000/cc were killed in $1\frac{1}{2}$ hour by 1 ppm AgNO_3 , and in $1\frac{1}{2}$ to 2 hours by 0.1 ppm at 22 C. At 8 C contact time required was $2\frac{1}{2}$ to 3 hours; thus, effect of temperature with AgNO_3 did not appear to be as great as with Ag ions. Addition of AgNO_3 to broth left AgNO_3 inactive, probably because of its combination with medium.

199. THE OLIGODYNAMIC ACTION OF SILVER IN THE TREATMENT OF WATER (in English), J. Gibbard, Can. P. H. J., 24:96 (1933). Reported on 15 months' experience with sterilizing water by Ag-covered porcelain rings. Under favorable conditions water containing several million *B. coli*/cc could be apparently sterilized in 2 hours, and under unfavorable conditions in 24 hours. By date of paper, Gibbard could not show bacteriostasis on *B. coli*. Activity required 7 hours' contact at 8 to 10 C and only 2 hours at 22 to 25 C. Presence of organic matter retarded oligo. action; slight retardation was produced by light. Amount of Ag adsorbed by water in activation varied directly with contact time of metal. Could not recommend Ag for practical application because of inhibitions produced by temperature, and presence of organic and inorganic substances.

200. BACTERICIDE AND GROWTH INHIBITION BY SILVER NITRATE IN NUTRIENT MEDIA (in German), G. Glück, Arch. f. Hyg., 110:38 (1933). Investigated action of AgNO_3 on *B. coli* from 24-hour culture at 37 C agar slants suspended in aq. dest., and determination made from smears on endoagar. All glassware was of Jena glass, soaked for 24 hours in 15 percent HNO_3 to eliminate oligo. pollutions. H_2S was used to neutralize activity of AgNO_3 in bacteria test sample at any given time. In non-diluted serum with H_2S applied after 72 hours' contact, 10 ppm AgNO_3 produced growth inhibition; bactericide required 20 ppm; 4 ppm was entirely indifferent. Observed aq. dest. to add to bactericidal effect of AgNO_3 . With 24-hour contact 0.01 ppm AgNO_3 was bactericidal, while 0.008 ppm left 1 pair of germs viable. Addition of small doses of AgNO_3

produced no turbidity in Leipzig tap water containing no free CO_2 , 28 ppm chlorides, and 10.4 grains per gal hardness. Without neutralization by H_2S , 0.2 ppm AgNO_3 in tap water was bactericidal to *B. coli* in 24 hours, and 0.02 ppm in 48 hours. Adding CO_2 to aq. dest. without H_2S , showed following results for bactericide in 24 hours: 0.0 CO_2 = 0.007 ppm AgNO_3 , 2.0 ppm CO_2 = 0.007 ppm AgNO_3 , 23 ppm CO_2 = 0.02 ppm AgNO_3 , 352 ppm CO_2 = 0.05 ppm AgNO_3 , and 1408 ppm CO_2 = 0.1 ppm AgNO_3 . In tap water CO_2 effect was less than in aq. dest. Addition of N/1000 down to N/100,000 of HCl definitely retarded bactericide of AgNO_3 . Weaker acids were much less effective. The addition of NaOH or NH_4OH exerted no effect on oligo. action of AgNO_3 . Solutions of NaCl inhibited in presence of 1 ppm NaCl. Carbonates and nitrates of Ca and CaCl_2 were ineffective to oligo. Observed that in presence of nutrient media, serum has greater inhibition of oligo. than do electrolytes.

201. TELERGY OF METALS ON MICROBES (in French), G. A. Nadson and C. A. Stern, Ztbl. f. Bakt., 88:320 (1933). Suspended various metals 1 mm above media surfaces inoculated with various bacteria or yeast, with action continued for 2 to 3 days at 20 to 22 C, and with colonies on 4th or 5th day. Hundreds of tests gave them regular results showing that bactericide occurred, increasing with increasing atomic number of metals tested, and decreasing with distance between metal and infected surface. Salts of Cu and Pb were observed to be weaker bactericidal than their pure metals. Yeast was more sensitive than 2 test bacteria. Paper provided no screen to telergy, a 5 micron pad of paraffin screened slightly, and 20 micron screened considerably. Nadson and Stern felt that telergy was caused by radioactivity of ambient, causing metal to produce secondary radiations of considerable bactericidal power.

202. INVESTIGATION OF THE OLIGODYNAMIC ACTION OF COPPER (in German), W. Schwartz and H. Steinhart, Arch. Mikrob., 4:301 (1933). A continuation of their work with *Aspergillus niger* reported in their previous paper (q. v. supra). After washing mycelles repeatedly, about 2/3 of original Cu in test solution was retrieved, and balance was retained by them. In another run, only 50 percent of Cu could be removed. Schwartz and Steinhart concluded that removable Cu was held by cells through adsorption. They could not indicate final locale in cells of retained Cu. They did feel that primary changes caused by heavy metals on living cells should be sought for in protoplasmic membranes, since it is here that first contact is made with living proteins. Change probably is one of permeability.

203. ON THE CONTINUOUS OLIGODYNAMIC EFFECT OF ELEMENTS ON BACTERIA (in English), Y. Seuderling, Soc. Med. Fen. Duo. Acta.,

Vol. 16, No. 8 (1933). Reviewed work of previous investigators. His work was investigation of oligo. effects of various metals embedded in infected nutrient media in petri dishes. Relative values of oligo. action, and sensitivities of 40 different bacteria were determined from studies of sterile zones produced in media. Many graphs, charts, tables, and photographs were included. His conclusions confirmed findings of Murto (q. v. supra).

204. NEW DATA ON THE ACTION OF FILTERS WITH SILVER SAND FOR THE DISINFECTION OF WATER (in English), V. A. Uglov and T. V. Uglova-Ovchinnikova, Voenno. Med. Zhur., 4:95 (1933). They constructed 25 l/hr sterilizing filter consisting of steel drum divided by partitions to give head chamber, purifying section, and treated water storage section. Ag-covered sand in filter column in lower part of drum provided sterilization. Their tests on infected river water showed reduction of *B. coli* from 96,500/cc to 0 within 6 hours from start of filtration. Methods of covering sand grains with Ag were given.

205. STERILIZATION OF SWIMMING POOL WATER BY KATADYN (in German), Viesohn, Ges. Ing., 56:316 (1933). Described Electro-Katadyn installation for shallow pool at Frankfurt (a. M.) Stadium, by Deutschen Katadyn G. m. b. H. of Munich in 1931. Equipment operated at 4 to 4.5 volts, 2A, and imparted Ag dose of about 100 gamma/l at 12 C. He found that the pool walls and the filter adsorbed some Ag. Obtained thereafter thorough bactericide and algacide. Three weeks after last Ag dose, water in pool was still active, showing residual Ag of 40 gamma/l. In 1932, repeated tests showed all samples negative for *B. coli*. Initial dose of 200 to 400 gamma/l was required to saturate walls; thereafter, only 50 gamma/l was required for sterilization.

206. IONIC SILVER STERILIZATION (in English), C. H. Brandes, Ind. and Eng. Chem., 26:962 (1934). Described various developments of Krause for practical application of Ag to water sterilization. Described action of Ag-activated water. Stated that bactericide dose was 0.05 ppm for 10-minute to several hours' contact periods, and up to 0.6 ppm for more prompt action. Electro-catadyn equipment was described: There is tendency for Ag to plate out of solution very slowly, depending upon nature of containing walls. Activity of Ag-water is lost very slowly with storage. Stated that for clear drinking water at over pH 7.0, only 0.05 ppm Ag with 1-hour contact is sufficient for complete sterilization. Higher doses required for turbid water. For swimming pools, 0.15 ppm needs to be added to makeup water only to keep water permanently sterile. Electrodes of Ag require renewal only once yearly. Heidelberg water supply is treated by Electro-catadyn method. Numerous swimming pools in England have been so equipped.

207. THE OLIGODYNAMIC ACTION OF METALS WITH PARTICULAR REGARD TO THEIR APPLICATIONS FOR RENDERING WATER POTABLE (in Italian), O. Casagrandi and A. Sepilli, Riv. Biol., 16:14 (1934). Reviewed work of previous investigators. Casagrandi and Sepilli investigated action of Katadyn jars (containing Ag-covered bodies) with various raw and filtered waters. Observed intense bactericide of *B. coli*, dysent. Flexner, Yong, Shiga-Kruse; *B. typhi*, faec. alcali., and *Vib. cholera*. Bacteria native to water were found more resistant. Electrostatic measurements indicated that bacterial suspensions lost some electric charge after being contacted with Ag ions, probably because of fixation of ions on bacterial cells. All a-spore pathogens were killed within 2 or 3 hours.

208. SILVER PROVES EFFECTIVE IN WATER STERILIZATION (in English), Anonymous, Chem. and Met. Engr., 41:7 (1934). Dealt with electric Katadyn process of Krause. Mentioned unit installed by Congressional Country Club, near Washington, D. C. for their 150,000 gallon pool. Action of Ag requires 30 minutes to several hours. Small amount of Ag required is harmless to human beings. Contact by Ag-covered bodies inefficient for large quantities of water. Electric method can be applied for continuous flow treatment. Energy consumption less than 0.001 kilowatt hours per ton of water treated, and Ag cost should be no more than 0.1 cent per ton of water for drinking purposes. Neutral and alkaline water accelerate oligo. action, but acid retards it. Suspended matter causes loss of Ag by adsorption. Operation of activation is automatic; Ag electrodes easily removed and cleaned. Installations already made include municipal water plant in Heidelberg, swimming pool in Frankfort a. M., ice plant in Dresden, brewery in Munich, and on new German cruiser "Königsberg."

209. EXPERIMENTAL CONTRIBUTION TO THE MANNER OF ACTION OF ANTISEPTIC SUBSTANCES (in German), Rudolph Freund, Biochem. Zts., 273:365 (1934). Freund's work was mainly in regard to therapeutics. His work with metal-covered adsorbents substantiated findings of previous oligo. investigators.

210. ON THE QUESTION OF ARGYROSIS (in German), Werner Gerlach, Klin. Wochs., 13:797 (1934). Gerlach's work with therapeutic doses of various Ag compounds on dogs showed Ag stored immediately and abundantly in eyes and internal organs.

211. KATADYN AND CIDER (in German), H. Gretler, Schw. Apo. Ztg., 72:600 (1934). Five-year old cider placed in Katadyn flask became clean, sterile, and tasty, thus being saved from going to waste.

212. ON THE OLIGODYNAMIC TREATMENT OF DRINKING WATER BY MEANS OF VARIOUS KATADYN METHODS (in German), H. Gutschmidt, Zts. f. Hyg. u. Infek., 116:421 (1934). Investigated variations in resistance to Ag of 160 different B. coli strains. Emulsions in sterile tap water activated by Katadyn-Ag, resulted in rapid death for some, very slow death for others, but majority were dead in 5 hours. Those obtained from water were more resistant than those from faeces. Cultured B. coli were less resistant. Within each individual group great variations in resistance were observed. Concluded that resistivity could hardly be ascribed as property of any individual strain. Of pathogens, Gutschmidt investigated 40 various strains of B. typhi., 30 of B. paraty.-A, 30 of B. paraty.-B, and 20 of Vib. cholera. All showed variations of resistance to Katadyn-Ag. Observed that 20,000/cc of some B. typhi. and paraty. took 6 hours' contact for bactericide, while B. coli took 4 hours. But could not draw conclusions from cultured pathogens, as to resistance of pathogens in their natural water habitat. Found Katadyn filters to give faster bactericide than Katadyn flasks. With Electro-Katadyn they observed optimum current strength on Ag dose above which no improvement in bactericide was observed. With Katadyn filter at 60 l/hour flow rate, death of B. coli and typhi. at 20/cc occurred in 2 hours, and at 20,000/cc in 4 hours. At 240 l/hour flow rate, death of B. coli and typhi. at 20/cc occurred in 24 hours, and 20,000/cc in 48 hours.

213. DEVELOPMENTS WITH KATADYN FOR WATER STERILIZATION (in German), A. Herrmann, Schw. Apo. Ztg., 72:599 (1934). Could get no killing of spore-forming water bacteria, yeast, and molds with Katadyn-Ag impregnated filter elements even after 22 days' contact; best obtained was 93 percent elimination. Water activated by Electro-Katadyn with 100 gamma/l killed 500,000/cc of the colityphi. group in 2 hours. Found Strept. just as sensitive; definitely resistant were Micro. roseus, and Sarc. aureus; indifferent were B. subt. and mesentericus; growth of mold spores was retarded.

214. ON OLIGODYNAMY AND ITS APPLICATION IN PRACTICE (in German), F. Hoder, Forts. d. Med., 52:453 (1934). Commercial aq. dest. was found to contain 0.1 ppm Cu = 100 gamma/l. Aq. dest. from tap water in copper still contained 0.02 ppm Cu = 20 gamma/l. "These findings are not without meaning for bacteriological practice." Oligo. pollution may be removed by redistilling in glass and preventing further contact with metals.

215. DISINFECTION OF WATER BY THE OLIGODYNAMIC ACTION OF SILVER (KATADYN PROCESS) (in German), G. Joachimoglu and N. Klissinius, Chem. Ztbl., 2:1970 (1934). Summary abstracted from original in Prakt. Akad. Athen. 8:197 (1922). They investigated

performance of Catadyn equipment on various Greek river waters. Kind of equipment, Ag dose or whether water received filtration before sterilization was not stated. They observed that *B. coli* com. suspended in sterile aq. dest. were killed by Catadyn, but additions of NaCl, Na_2SO_4 , or KNO_3 retarded bactericide considerably. Sewage containing H_2S and 10 ppm ammonia was disinfected after diluting 80 times with sterile aq. dest. Bactericide in Athens water containing 0.006 ppm ammonia, was too slight to be of practical value.

216. THE STERILIZATION OF SPIRIT VINEGAR BY MEANS OF THE KATADYN PROCESS (in German), Heinrich Kreipl, Fruit Prods. J., 13:337 (1934). Reported on laboratory investigations in Germany on Elektro-Katadyn equipment for sterilization of vinegar. He observed that 15 seconds' contact was sufficient for such sterilization. Activation required was 150 to 250 gamma Ag/l.

217. BASIS OF THE NEW SYSTEM OF SILVER ANTISEPSIS AND CHLORINE DISINFECTION (in German), Walter Kruse and M. Fischer, Arch. f. Hyg., 113:46 (1934). Kruse and Fischer described their method of activating silver-coated medical instruments by electrolysis. Their wound sterilizing liquid, "Silbermolke" contained electrolytically produced AgCl. They also prepared "silver powder" for antiseptis and "Physiological Chlorine" electrolytically produced from NaCl solution.

218. THE NEW SYSTEM OF SILVER ANTISEPSIS AND CHLORINE DISINFECTION (in German), Walter Kruse and M. Fischer, Munch. Med. Wochs., 81:49 (1934). They activated silver-plated instruments by electrolysis in chloride or carbonate medium, thereby forming active Ag chlorides or Ag carbonates on silver surfaces. Believed that Ag can be toxic to humans only with long use of large doses. Discolorations can be noted only after total consumption of 15 grams of Ag. Lethal quantity for animals is 10^{-5} its body weight if resorption is immediate. Claimed that reducing action of S compounds of tissues, or of SH substances from bacterial action, are insufficient to inhibit oligo. action of activated Ag. Described their method of providing sterilization with highly active Cl ions, produced by current from non-reacting electrodes ionizing chlorides present in any natural or distilled water.

219. KATADYN AND ELECTRO-KATADYN (in German), Felix Linke, Zts. ges. Krankhsw., 8:170 (1934). Pointed out that 40 gamma Ag/l contains 2.4×10^{17} Ag ions/l, while with bacteria at $2.4 \times 10^6/\text{cc}$ there are 2.4×10^9 bacteria/l. Thus, Ag ions = 10^8 the bacterial count. Presented photographs of Electro-Katadyn installations.

220. STERILIZATION OF WATER WITH SILVER COATED SAND (in

English), S. Moiseev, A. W. W. A. J., 26:217 (1934). Reports on experiments carried out at Leningrad Branch of Scientific Research Institute of Water Supply and Sanitary Engineering, Leningrad, U.S.S.R. Moiseev's report on work with Ag-covered sand is difficult to evaluate because of some confusion in determination of what he calls contact time. Filtrates of Neva River water showed 0 to 49 colonies/cc, average 8, compared to 4 to 26 colonies/cc, average 20 for chlorinated Neva River water. Chlorinated water showed once positive *B. coli* in 1 cc and 3 in 100 cc; Ag filtrate showed none in 100 cc. Concluded that until Ag-sand was coated, its sterilization was better than of Cl_2 . Mechanical cleaning of Ag-sand restored its activity. He concluded that pathogens were more sensitive to Ag than to typical saprophytes of air and water. Inoculated river water, prefiltered, passed through Ag-sand bed. Coagulated water before filtering contained 300 to 60,000 bacteria per cc, average 13281/cc. Before Ag-sand filter bacteria count averaged 10539/cc. Immediately after Ag-filter count was 0 to 124/cc. Coagulated water direct to Ag-filter without prefiltering, showed *B. coli* positive in 10 cc 3 times (9 percent), and 18 times 100 cc (51.4 percent). The Ag-filtrate then showed no samples positive for *B. coli*. This indicated that oligo. Ag could sterilize large amounts of bacteria in water, and that in spite of fouling, Ag-sand acted vigorously for long time. Chlorination of Neva River water with 0.07 ppm residual Cl_2 showed reduction from 598 to 16 bacteria/cc, or 2.6 percent survival, while Ag-sand reduced from 10539 to 12 or 0.1 percent survival on immediate contact, to 0.03 percent after 2 hours. Chlorinated water showed 1 positive *B. coli* for 100 cc samples, and Ag showed none. Ran tests for comparing effectiveness of 145 different kinds of Ag-sands. He concluded that relation between weight of water being disinfected and weight of Ag on sand was unimportant. Criterion was amount of active Ag surface exposed to water.

221. EFFECT OF SILVER OR FORMALDEHYDE ON BACTERIAL GROWTH (in German), Werner Oertel, *Arch. f. Hyg.*, 113:71 (1934). Studied effect of Kruse and Fischer's "Silbermolke" (lit. "milk of silver," a preparation of AgCl in protective colloids, to be used for medication) on *B. coli* and *Staph.* in bouillon. Indicated stimulated growth for low Ag concentrations. With further dilutions growth varied between retardation and stimulation. Complete bactericide of *B. coli* was obtained with 10 ppm of Silbermolke with 10 hours' contact.

222. OLIGODYNAMIC EFFECT OF SILVER OXIDE AND KATADYN-SILVER (in German), Fritz Ottenssooser, *Arch. f. Hyg.*, 113:258 (1934). His laboratory investigations demonstrated similar sensitivity of all of 19 different strains of *B. coli*. No difference was shown for difference in age, freshness, whether from water, stool, urine,

or blood. Ag_2O was as effective bactericide on *B. coli* as AgNO_3 if both doses were of same Ag ion concentration. Sterilized and filtered river water activated by Katadyn-Ag jar was as bactericidal as aq. dest. prepared in same way. Vib. metch. in river water at 630/cc was sterilized in 40 minutes with 0.24 ppm Ag, and in 10 minutes with 0.48 ppm Ag, both at room temperature; however, they appeared more resistant in activated water than in river water. Vib. were 10 times more sensitive than *B. coli*, in fact, so sensitive that he could use them to indicate presence of oligo. Ag adsorbed by glass walls. Freshly activated river water killed 630 germs/cc in about 30 minutes, while water contacted by Ag $2\frac{1}{3}$ hours, then stored 2 to 3 weeks, showed no killing after $2\frac{1}{2}$ hours contact of inoculation with activated water. "Since this difference is very great, it must be taken for granted that investigations indicate reduction in activity by storage, and adsorption of Ag by glass walls of storage containers." Katadyn-silver produced by carefully heating AgNO_3 and allowing it to glow weakly. Flaky powder thus produced was used to impregnate asbestos, clay, or other inert carriers; or carrier was first wetted with AgNO_3 solution then heated. Commercial Katadyn-Ag contains also some other metal of different electro-potential, thereby increasing activity of Ag. Katadyn jar was not recommended for indiscriminate use, or for large volumes of water.

223. OLIGODYNAMIC ACTION OF METALS (in Italian), Guido Piazza, Gior. Med. Mil., 82:323 (1934). Investigated practical military application of Katadyn water sterilization. Natural surface water containing 1000/cc bacteria, including chromogens, sporogens, liquifiers, and *B. coli*, incubated at 37 C, whereupon it showed 2000 *B. coli*/l. Without filtering, samples of this water were placed in Katadyn flask, maintained various periods at 37, 18, and 0 C, then counted in gelatine plates, agar plates, and *B. coli* titrated by Abba method in lactose broth. With 30 minutes' contact at 37 C, *B. coli* were negative while bacterial counts were down to 14/cc in agar, and 350/cc in gelatine. Count in agar became zero in 2 hours, and gelatine count in 4 hours. At 18 C, *B. coli* became negative in 1 hour, agar count became zero in 3 hours, and gelatine count in 4 hours. At 0 C, *B. coli* became negative in 4 hours, and agar count became zero in 8 hours. Same water filtered before being placed in Katadyn jar showed thus: at 18 C *B. coli* became negative in $1\frac{1}{2}$ hour, agar count became zero in 2 hours, and gelatine count in 3 hours. Temperature effects were observed similar to previous test. Tap water sterilized by boiling, inoculated with *B. coli* to give from 50/l to 50,000,000/cc, then placed in Katadyn flask without prefiltering, at 18 C. Various contact periods showed *B. coli* killed thus: $1/20$ cc in 15 minutes; 1/cc in 30 minutes; 25/cc in 1 hour; 1,000 to 5,000/cc in 3 hours; 20,000 to 50,000/cc in 10 hours.

Tap water, sterilized, activated in Katadyn flask for various periods, removed, then inoculated with *B. coli* at 1/cc to 10,000/cc, showed that 15-minute Ag-activated water later sterilized in 2 hours at 18 C. With 1000/cc, 1 hour-activated water sterilized in 30 minutes at 18 C; for 5,000/cc, 3 hour-activated water sterilized in 2 hours; for 10,000/cc it took 2 hours with 6 hour-activated water. Tap water inoculated with emulsion from faeces, passed through a Katadyn-filter at 18 C produced following *B. coli* bactericides: 50/cc in 15 minutes after Ag-filtration; 1,000 to 5,000/cc in 2 hours; 10,000/cc in 3 hours; 50,000/cc in 8 hours; and 100,000 in 12 hours. Piazza's work indicated that bactericide in Katadyn flasks varied with contact period. Light had no appreciable effect. Bactericide of Katadyn-flask on *B. paraty.*-A appeared thus at 18 C: 100/cc in 3 hours; 1,000/cc in 4 hours; 10,000/cc in 6 hours; 20,000/cc in 12 hours; and 100,000/cc in 24 hours. Similar results were observed with *B. paraty.*-B, and other bacteria. He indicated contact periods for bactericide varied with genus of bacteria. They found addition of various amounts of NaCl had no influence on oligo. bactericide. Intensity and speed of bactericide varied directly with Ag surface. Protozoa with bacteria developed profusely in Katadyn flasks. No effect was produced on *B. coli* and bacteria in milk. Described colorimetric method for indicating presence of minute amounts of metals. Natural water, heavily infected with *B. coli*, *faecalis*, etc., contacted for various periods in Katadyn-flasks, withdrawn, left standing 1 to 6 days, placed in culture; showed no recovery of vitality. Samples after Katadyn were treated with 1 percent Na citrate solution, then with 2 percent Na thiosulfate solution; recovered *B. coli* showed no revival, even with only 2 hours' contact with Ag. He concluded that because of required contact time, and lack of good bactericide indicator Katadyn method was not to be preferred by Army over other chemical methods of sterilization, but with perfection of equipment it is possible that it will become suitable for Army use.

224. THIOI COMPOUNDS AND ENZYMES (in German), Theodore Bersin, Erg. Enzymf., 4:68 (1935). Study of effect of metals on cellular biology. Cu and other heavy metals, from traces up to 2×10^{-4} , catalyze O_2 -oxidations of glutathiois to disulfides -- GSH to GSSG; Cu was most active catalyst, by far. Many reversible inhibitions of enzymes by heavy metals are to be ascribed to formation of mercaptans with HS groups of macro-molecules acting as enzyme-carriers -- the enzyme-essential HS is thus blocked. Reaction with HCN produces as transfer product a metal cyanide, releasing original HS group and reactivating blocked enzyme. Substances that paralyze or inhibit action of enzyme usually give reversible actions. Metals can be removed and urease can be reactivated by HCN. Inhibition can be produced by

envelopment of enzyme macro-molecule by non-specific substance blocking its contact with the substrate; also by surface-active narcotics, such as decomposition or metabolic products. Inactivation of enzymes by mild oxidizer can be reversed by mild reducer. Substances that disrupt or destroy enzymes produce irreversible chemical changes in active groups; oxidizers, such as selenic acid, ozone, I, KMnO_4 , or O_2 plus heavy-metal catalyst can cause the enzymes to proceed to non-regenerative forms. Thiols influence either substrate or enzyme activity. "Various metal traces are necessary concomitants for thiol-systems, important for intracellular metabolism Possibly an increase in concentration of catalyst element, or its decrease, may lead to disturbance of enzyme activities. Such overdose is found in heavy metal poisoning to which must be ascribed oligo. action. . . ."

225. A SPECTROGRAPHIC DETERMINATION OF MINOR CHEMICAL CONSTITUENTS IN VARIOUS WATER SUPPLIES OF THE UNITED STATES (in English), M. M. Braidech and F. H. Emery, A. W. W. A. J., 27:557 (1935). Reported that Denver city water may contain as much as 0.2 to 0.3 ppm soluble Ag.

226. THE OLIGO-DYNAMIC EFFECT OF METALS (in English), C. P. Callister, Soc. Chem. Ind. Vict. Proc., 35:1068 (1935). Surveyed previous literature. Made confirmatory experiments with AgNO_3 on *B. coli* in aq. dest. Stated that 0.05 mg/l did not sterilize in 1 hour but did in 2 hours. Obtained same results in raw water. With 0.03 ppm found growth even after 3 hours' contact. *B. coli* grew free in Ag-treated media because nitrogenous matter therein adsorbed Ag ions.

227. DESIGN AND OPERATION OF SWIMMING POOLS (in English), J. H. Dorroh, A. W. W. A. J., 27:106 (1935). Electro-Katadyn equipment at Congressional Country Club, Washington, D. C., was placed in operation July 4, 1935. On August 30, 1935, two qualified bacteriologists reported water to be entirely free of pathogens and algae. Pool had not been emptied since opening day.

228. QUANTITATIVE DETERMINATION OF SMALL AMOUNTS OF SILVER WITH DITHIZON (in German), H. Fischer, G. Leopoldi, and H. von Uslar, Zts. anal. Chem., 101:1 (1935). Described colorimetric method for indicating 10 to 120 gamma Ag/l. Indicated other metals also.

229. DETERMINATION OF SILVER IN KATADYN-TREATED WINE AND OTHER LIQUID FOODS (in German), A. Jendrassik and Sz. Papp, Zts. Unters. Lebsm., 69:369 (1935). Reviewed existing indicator methods. Described method to indicate 20 gamma Ag/l, using no more than 1 liter and less than $1\frac{1}{2}$ hours, oxidation of organic

matter by HNO_3 , H_2O_2 , and H_2SO_4 . Precipitate was treated with H_2S and other reagents to give final Ag precipitate in form of chloride which was filtered and weighed.

230. PRESENT STATUS OF KATADYN DEVELOPMENTS (in German), A. Karsten, Ges. Ing., 58:736 (1935). Described pocket-size Electro-Katadyn operated by small flashlight battery. Sterilizes 1 liter per minute. Contact of 3 minutes imparts sterilizing residual. Battery is good for 3 to 4 months' use. Mentioned Electro-Katadyn installation for fruit juices at 500 l/hour; and one for a margarine factory at 80 cu. met./hour.

231. THE CUMASIN SYSTEM AND HAND DISINFECTION (in German), W. Kruse and M. Fischer, Klin. Wochs., 14:1180 (1935). Described their "Sina-Chlor-Activator" for the medical profession, as means for sterilizing hand-washing water. Consisted of platinum immersion electrode apparatus, to work at 12 volts, d-c, 2.6 amp. Produces 30 to 60 ppm Cl_2 in 1 to 2 minutes, and 960 ppm in 40 minutes. They also described their "Active-Cumasin Powder," an Ag preparation, and their "Cumasin-Vulkan Powder, KF."

232. ON THE OLIGODYNAMIC ACTION OF SILVER CHLORIDE (in German), F. Lieb, Ztbl. f. Bakt., 133:308 (1935). Reviewed previous literature on activation and de-activation of oligo. metals. Lieb accepted theory that oligo. was due to metal surface compound. Sought for oligo. substance that would be soft and workable, and of long duration. Chose AgCl , melting point at 455 C, solubility 10^{-5} , soft and workable. He precipitated AgCl from AgNO_3 and HCl , filtered it, melted it in hard glass tube, broke up tube, and obtained AgCl in small rods of 3 to 4 mm diameter and 1 cm long. These embedded in gelatin inoculated with B. paraty.-B produced sterile zones. Treating with H_2S , unconsumed AgCl turned black and was easily separated from gelatin. These rods were kept in flowing water for 3 days, again tested on B. paraty.-B, producing sterile zones of same size. After 6 months' retention in flowing water, the AgCl rods were still slightly effective.

233. MITOGENETIC EFFECT OF YEAST AND OF OLIGODYNAMIC RADIATION FROM METAL (in English), Margaret B. MacDonald, Iowa St. Col. J. Sci., 9:587 (1935). Mac Donald's investigations tended to indicate the ability of metals to exert indirectly influence on biological action. Yeast cultures were placed in Erlenmeyer flasks on pieces of freshly cleaned sheets of Cu, Fe, Pb, and Al, with control on cardboard. Daily counts of samples from flasks incubated on metal were always higher than of control, as were turbidities. These results were observed for 6 different yeasts. For all metals tested, uniform increase in growth was observed for cultures in ordinary glass tubes, and significant gains in thin-

walled glass tubes; but growth inhibition was noted in quartz culture tubes. Non-inoculated culture media placed in glass tubes, and these surrounded by various metal jackets were left standing some time in cupboard at room temperature. Metal jackets were then removed, cultures were inoculated, incubated, and counted. Results were very irregular but ". . .they do furnish evidence of reception by medium of radiation from metal jackets." She believed that her experiments established fact of sensitivity of yeast cells to indirect oligo. action of metals separated from cultures by glass walls.

234. BACTERICIDAL POWER OF WATER SUBMITTED TO THE COMBINED ACTION OF SILVER METAL AND DIRECT ELECTRIC CURRENT (in French), Nicolas Metalnukoff, Compt. Rend. Acad. Sci., 201:411 (1935). Used Ag anode and cathode of carbon or of other non-active conductor, and current of 0.3 to 4.0 milliamperes at 1.5 to 4.5 volts. With Ag surface of 16 cm², 1 liter Seine River water became bactericidal in 1 to 2 minutes to subsequent *B. coli* contacted for 1 to 3 hours. Ag sheet of same or larger surface without electric current, or 2 carbon electrodes with current, or carbon anode with Ag cathode produced no bactericidal activity. Activation of water varied with amount of Ag surface or strength of current. Sporulated *B. ephestiae*, *B. cazabon*, and *Asperg. niger* were killed in 2 to 3 hours by tap water activated 3 minutes by Ag anode of 45 cm² and 50-milliampere current at 10 volts. *B. coli* and *Staph.* were dead in 3 hours.

235. GERMICIDAL PROPERTIES OF WATER CONTAINING MINUTE AMOUNTS OF SILVER (in English), R. Meyers and J. C. Mauer, J. Bact., 29:7 (1935). Investigations by Meyers and Mauer were carried on in Research Laboratories of the National Dairy Products Corp., Inc., Baltimore, Md. They worked with dilute solutions of AgCl, AgNO₃, Ag acetate; with colloidal Ag prepared by passage of electric arc between 2 Ag wire electrodes immersed in aq. dest.; and with Electro-Katadyn set. The waters used were sterilized river water with alkaline reaction, and sterile aq. dest. with 10 ppm of calcium carbonate added. All 5 types of Ag in amounts of 0.1 to 0.15 ppm of Ag ions killed *E. coli* at 250,000/cc in 2½ hours. *Staph. aureus* was slightly more resistant.

236. A COLORIMETRIC METHOD FOR THE QUANTITATIVE DETERMINATION OF SMALL AMOUNTS OF SILVER (in English), Irl C. Schoonover, J. Res. N. B. Stds., 15:377 (1935) (RP836). Schoonover described indicator method based on that of p-dimethylamino-benzal-rhodanine method of Feigl (q. v. supra) and of Kolthoff (J. Amer. Chem. Soc. 52:2222 (1930)). He also investigated adsorption of metals by glass. Found high adsorption of Ag in flasks of soft glass; varied with increasing ratio of flask surface to volume. Pyrex

adsorbed less than soft glass, and fused silica adsorbed even less. Found large adsorption by pyrex when evaporating from pyrex beakers, but little or none with fused silica dishes. Concluded that soft glass was quite unsuitable for use at any point in handling of Ag solutions in determination of small quantities of Ag. The adsorption was increased when alkali was used for treating soft glass surfaces, and decreased when cleaned with acid-dichromate solution.

237. ON THE NEW OLIGODYNAMIC ACTING CHEMICAL COMPOUNDS OF SILVER AND MANGANESE (in German), W. Uglow and G. Gan, Zts. f. Hyg. u. Infek., 117:488 (1935). Work of Uglow and Gan covered investigations of action of various Ag-covered sands. Compared action of Uglow's sand with Ag deposited by NH_4OH and formaldehyde, as against Moiseev's sand having Ag deposited through reduction by glucose or Rochelle salts. They presented details for preparing their "Black" Ag-sand. In a tube 3 cm diameter was placed 100 g of 0.5 to 1.0 mm "black" Ag-sand, 10.5 cm deep, with surface area of 7 cm^2 . Through this was run Neva River water infected with *B. coli* varying from 28,000 to 700,000/cc and at flow rates from 22 to 33 cc/min. All tests showed zero *B. coli* counts immediately after filtration. Raw Neva River water with 795 *B. coli*/cc at flow rate of 85 cc/min was sterile immediately after filtration. To 250 cc of 0.25 percent albumin solution they added *B. coli* from agar slant culture to give bacterial concentration of 855,700/cc of solution. At a filter rate of 17 cc/min, the bacterial count was 1700/cc (99.8 percent reduction) immediately after filtration and zero in 1/2 hour. At faster filtration rates, retardation of bactericide by albumin was greater. High hardness (80 gpg) provided no inhibition to oligo. action of black sand. However, 280 ppm additive NaCl did retard bactericide. After Ag-sand filtering with 60 l of sewage-polluted water of 50 ppm BOD, they treated 250 cc tap water infected with *B. coli* at 1,700,000/cc, and filtered through same Ag-sand bed; after 1/2 hour, removal was 99.93 percent. Organic matter was best removed from Ag-sand by washing with permanganic salt solution acidified with H_2SO_4 . Found better results after first coagulating and settling water. Believed that their method of preparing Ag-covered sand produced thereon Ag-Mn compound slightly more soluble than Ag-metal. Their analysis showed coating contained 1.37 percent Ag and 0.037 percent Mn. They calculated that 10 kg of "black" Ag-sand should sterilize 38 tons of water.

238. INVESTIGATIONS ON THE PURIFICATION OF WATER WITH THE KATADYN METHOD (in Italian), E. Bertarelli, E. Caserio, and I. Peragallo, An. d'ig., 46:449 (1936). Described various Katadyn equipments of Krause. They observed that stronger current than is necessary with Elektro-Katadyn produced change in color

of water. To prevent retardation of oligo. Ag bactericide by H_2S , he first aerated water. Using pocket size Electro-Katadyn on water with 250,000 to 500,000 B. coli/cc and at 40 milliamperes and 2 volts, sterility resulted with 0.4 ppm Ag in $1\frac{1}{2}$ hours at 25 C. B. Coli at 50,000 to 100,000/cc was sterile in 1 hour with 0.26 ppm Ag.

239. TREATMENT OF FOX RIVER WATER BY THE SILVER MINERAL PROCESS (in English), W. U. Gallaher, A. W. W. A. J., 28:1933 (1936). Described "Super-Ionite," American product, synthetic granular material made up of Ag in combination with base-exchange silicate. The Ag is dispersed throughout particle, not on surface alone. Bactericide depends upon the adsorption of bacteria on to Super-Ionite. Activity of material restored by passing through non-corrosive salt solution. In November and December 1935 Gallaher tested Model CH Super-Ionite Domestic Drinking Water System consisting of porous filter stone before column of Super-Ionite and 30-gallon pressure tank. From November 1 to 9, filtered water with bacteria, 20 to 4800/cc and B. coli 10 to 1000/cc, temperature of water at 50 to 42 F. After 726 gallons were treated, bacteria were only slightly reduced, while B. coli were completely reduced. After filter was cleaned but not reactivated, further filtration from November 12 to 19 with water at 38 F, obtained sterile water after 10 hours' contact; immediately after filtration B. coli was 65 plus 100 cc, but these results were under overload and over-run operating conditions. For normal operation of equipment on water at 33 F, turbidity 20, color 21, bacteria 60 to 1350/cc, B. coli 10 to 100/cc, produced filtrate with 0.29 B. coli after 10 hours' contact. With storage, 10 out of 11 tubes conformed to standards. He maintained that operation on cold, highly polluted river water with proper storage produced safe water according to U. S. Treasury standards. Should produce safe water from waters judged proper for chlorination, containing less B. coli than 100/100 cc, since test water contained 1,000 to 10,000/100 cc.

240. CONTRIBUTIONS TO THE STUDY OF THE OLIGODYNAMIC ACTION OF SILVER WITH SPECIAL REGARD TO THE SILVER-HALOGEN COMPOUNDS (in German), Ikeda Shingo, Ztbl. f. Bakt., 136:269 (1936). Activated sheet Ag by contact for 5 to 15 minutes with 0.005 percent $KMnO_4$, 0.5 to 1.0 percent H_2O_2 , or N/10 HCl. For electrolytic activation used mixtures of 0.35 percent NaCl with 1 percent of either Na, Br, KI, Na_2CrO_4 , or KCN. Ag electrodes 10 x 15 mm were suspended in these electrolyte solutions and current from battery was impressed across them for 3 minutes. Activation occurred at anode. Various forms of activated Ag-sheets were tested for relative bactericidal power by measuring sterile zones they produced in normal agar plates infected with B. coli and Staph. Was able to show

agar bactericidal subsequent to removal of oligo. Ag which had been imbedded therein for 24 hours; this bactericidal power was inversely proportional to length of time elapsing between removal of Ag and inoculation of agar. Agar free from chlorides showed stronger oligo. activation. He found that bactericide of AgBr was strongly inhibited by presence of NaBr but AgCl showed appreciable oligo. action with NaBr. Inhibition of oligo. action of Ag appeared above 2 percent NaCl and varied with its concentration. Inhibition by KCl commenced at 0.5 percent concentration. Organic matter from meat extracts retarded Ag oligo. action.

241. GERMICIDAL PROPERTIES OF SILVER IN WATER (in English), J. Just and A. Szniolis, A. W. W. A. J., 28:492 (1936). Pointed out fact that if Ag dose for water sterilization is 40 gamma/l, number of Ag ions thus provided amounts to 2.4×10^{14} /cc, which number is quite sufficient to contact with any number of bacteria usually present in water. In laboratories of Dept of Sanitary Engineering, State School of Hygiene, Warsaw, Poland, Just and Szniolis investigated effects of presence of minerals in water on electrical requirements for Elektro-Katodyn sterilizer. Ag quantities were found by analytical determinations. Increase of chlorides from 13 ppm to 255 ppm in tap water reduced Ag ions produced from 240 to 40 gamma/l. Increasing sulfates from 35 ppm to 120 ppm increased the Ag ions from 240 to 320 gamma/l. Their test data could provide no definite conclusions on influence of nitrates. Highest electrical conversion of Ag to ions obtained in tap water was 50.3 percent of theoretical, and 97.4 percent in distilled water. Working with sand filters and Ag-shavings, or Ag-sands, they sterilized B. coli infected tap water by 0.1 ppm Ag in 2 to 3 hours, and polluted water with same number of B. coli by 0.1 ppm Ag in 5 to 7 hours. Swimming pool watertreated with 0.2 ppm Ag showed bacterial counts in agar plates representing reductions of 91.5 percent in 30 min, and 99.5 percent in 3 hours. Demonstrated long time Ag residual characteristic of water activated with 100 gamma Ag/l remaining bactericidal over 3-month period. They observed rats were harmed when fed with water containing 0.4, 0.7, and 1.0 ppm Ag.

242. APPLICATION OF THE CUMASIN METHOD TO THE STERILIZATION OF DRINKING, BATHING AND PROCESS WATER, AND WITH SILVER IN LARGE PLANTS (in German), W. Kruse and M. Fischer, Ges. Ing., 59:312 (1936). By bacteriological examinations they determined that active agent in Electro-Katodyn practice was AgCl formed electrolytically on Ag anode only. They then assumed that during process, Cl ions were produced from chlorides present in any water and that they combined with Ag ions on Ag anode. They believed AgCl thus formed to be more oligo. than AgCl produced by other methods. They conceived idea of using anode of non-reacting

substance instead of Ag, thus permitting Cl ions produced by electric current to remain free in water and thereby sterilize it. They then developed 2 methods of sterilization: "cuma" -- cum argentum, or with silver, and "sina" -- sin argentum, without silver. Basic idea was to produce ionic Cl at anode in weak electrolytic solutions. Cumasin process was installed in city baths of Leipzig for bathing pool of 750 m³. Ag anode of 1 Kg lasted 3 to 4 weeks. From that time on, B. coli in 100 cc was never positive. Ag resistant saprophytes and low bacterial counts were observed.

243. ON KATADYN, PARTICULARLY THE NEW ELECTRO-KATADYN METHOD FOR WATER STERILIZATION (in German), A. Kufferath, Tech. Gemdbl., 39:177 (1936). Referred to works of previous writers and described various Katadyn developments of Krause. Referred to installation of Electro-Katadyn apparatus at municipal water plant near Heidelberg to treat 5 m³/hr, dosing Ag 30 to 50 gamma/l. Mentioned plant at Wallesby, England, and one in brewery in Munich for 3.5 to 4 m³/hour.

244. A CONTRIBUTION TO THE STUDY OF THE OXYGEN ACTIVATION OF METALLIC SILVER (in German), Franz Lieb, Arch. f. Hyg., 116:317 (1936). Investigated various means of making Ag metal oligo. active. Generally, oxidizers were found to be Ag activators. Fatty acids and H₂SO₄ were non-activating. Action of HCl was irregular. Application of HNO₃ produced soluble AgNO₃, but Ag metal surface was not coated with this oligo. compound. Reaction product of Ag and acid must be insoluble enough to permit formation of deposit or sheath on Ag surface, and soluble enough to impart oligo. action. Found chromic acid to meet these requirements. H₂S in presence of atmospheric oxygen can produce necessary oligo. product with Ag.

245. ON THE BACTERICIDE OF MERCURY (in French), M. Lisbonne and R. Seigneurin, Compt. Rend. Acad. Sci., 202:169 (1936). Natural waters with B. coli over 10/cc found sterile after few hours' contact with metal Hg at room temperature. One cc of Hg was placed in 1000 cc of suspensions of various microbes with following bactericidal results: B. coli of 2 x 10⁹/cc killed in 72 hours; Staph. 2 x 10⁹/cc in 72 hours; Staph. 2.2 x 10⁶ in 36 hours; Bruc. abort. 1.5 x 10⁶ in 24 hours; Vib. cholera 10⁹ in 24 hours. Water was made active with long-term residual by previous contact with Hg. Found freshly distilled, washed, and filtered Hg bactericidal for microbe suspensions in liquid vaseline; and was just as active in neutral as in acid or alkaline media. Absence of O₂ inhibited oligo. action.

246. BACTERICIDE OF MERCURY ON B. COLI IN CONTINUOUSLY FLOWING WATER (in French), M. Lisbonne and R. Seigneurin, Compt. Rend.

Soc. Biol., 122:18 (1936). They constructed sterilization tank and placed layer of Hg on bottom. Polluted water under pressure entered tank at bottom, forced to bubble through Hg layer, then collected in tank above Hg. Retention period was 4 to 5 hours, but draw off from top was continuous. Tests made with tap water at 5 to 20 l/hr flowing continuously, and infected twice daily with *B. coli* at 30 to 100/cc. Samples for determination of sterilization were withdrawn 8 to 12 hours after infection. First day's operation at 6 l/hour showed reduction of *B. coli* from 95,000/l to 100/l or 99.8 percent to 10/l on third day, or 99.98 percent; and produced complete sterility on fifth day of operation.

247. OLIGYDYNAMIC EFFECT OF SILVER AND OTHER METALS (in English), Anon., Ont. Res. F. Bul., Vol. 3, No. 9 (1936). They demonstrated formation of sterile zone in infected agar plate by Canadian silver dollar placed therein. They believed Katadyn sand beds too costly and too difficult to clean and to reactivate. Described Matzka process, which combines temperature differential with electropotential differential produced by contact of medium with two different metal plates.

248. ON THE DECREASED EFFICIENCY OF ELECKTRO-KATADYN INSTALLATIONS FOR THE PURIFICATION OF SWIMMING POOL WATER (in German), E. Remy, Zts. f. Hyg. u. Infek., 119:263 (1936). Investigated operation of Elektro-Katadyn equipment for shallow pool of Strandbade in Freiburg, Breisgau, Germany. Water recirculating from pool was sand-filtered before sterilization. Tests made in July 1936 showed negative for *B. coli* 3 hours after filling tank, but positive in 1 cc 2 days and 4 days later. Bacterial counts were always high. He concluded that filter installation was too small for pool load of 2500 m³, therefore imperfectly filtered water interfered with action of sterilization equipment.

249. EXPERIMENTAL INVESTIGATIONS ON THE ACTION OF KATADYNIZED WATER ON BACTERIA (in Italian), Luigi Schioppa, An. d'ig., 46:497 (1936). Used pocket-size Elektro-Katadyn for activating water with various concentrations of Ag. Used equal bacterial concentrations of 500,000/cc from 24-hour agar culture suspensions of Eberth. *B. coli*, paraty.-A and B, *Vib. cholera*, *Staph.*, and *Strept.* Results showed: 30 gamma/l -- slightly inhibitive on all bacteria only after 8 hours; 100 gamma/l -- large reduction after 2 hours, all sterile after 8 hours; 150 gamma/l -- inhibition after 1/2 hour, large reduction after 1 hour, all sterile after 5 hours; 200 gamma/l -- inhibition after 15 minutes, large reduction after 1 hour, all sterile after 3 hours; 260 gamma/l -- large reduction after 1/2 hour, all sterile after 1 hour. Same result was obtained by 260 gamma/l on 50,000 bacteria/cc. For

500,000,000/cc, 260 gamma Ag/l produced inhibition in 15 minutes to 1 hour and bactericide after 2 hours. For 500,000 bacteria/cc, larger Ag doses provided no better results. Optimum dose for sure sterilization appeared to be 260 gamma Ag/l.

250. SILVER: ITS PROPERTIES AND INDUSTRIAL USES (in English), B. A. Rogers, Irl C. Schoonover, and Louis Jordan, N. B. S. Circ., C 412 (1936). Rogers, Schoonover, and Jordan reviewed work of previous investigators. They stated that Ag sterilization process had met with considerable commercial success in Germany. Investigators at Research Laboratories of National Dairy Products Corp. in Baltimore working with Ag salts and colloidal Ag, sterilized *E. coli* of 3200 to 8000/cc in aq. dest. of pH 7.0 to 7.2, 20 C in $1\frac{1}{2}$ to less than 3 hours by 0.1 to 0.15 ppm Ag. Electro-catadyn and AgCl sterilized sooner. Dr. Robert Keilty in his "Experiments on the Bacteriostatic and Bacteriolytic Influence of Silver," unpublished report of 1935, submitted to sponsors of associateships on silver at the Nat. Bur. Stds, found Ag affecting bacteriolysis when in contact with bacteria in media. Cu was less effective than Ag. Authors found Electro-catadyn to be outstanding. Ag-activated water was observed to be bactericidal in $1/2$ to several hours.

251. CONTRIBUTIONS TO THE STUDY OF THE OLIGODYNAMIC ACTION ON DRINKING WATER STERILIZATION WITH PARTICULAR REGARD TO THE ELEKTRO-KATADYN (in German), Kenichi Chuda, Mitt. Med. Ak. Kioto, 19:745 (1937). Worked with pocket-size Electro-katadyn using Ag or Cu electrodes. Activated water placed in agar or gelatin media with water bacteria and *B. coli*, incubated 48 hours at 22 C; with pathogens, incubated 24 hours at 37 C. Found Ag more active than Cu for all bacteria tested. Ag dose averaged 0.175 ppm.

252. ON THE STUDY OF THE OLIGODYNAMIC ACTION OF SILVER (in German), Hans Fromberg and Josef Heiss, Ang. Chem., 50:679 (1937). Clean, pure Ag wire produced no sterile zone in agar plate infected with *Staph. aureus*. When AgCl placed about only one end of wire, entire piece became active and produced sterile zone all around it. Clean Ag wire used as electrode in NaCl solution became activated by coating with AgCl. When this touched non-active Ag wire in plate, latter became active and produced sterile zone. An AgCl activated Ag wire was placed in plate near another containing inactive Ag wire; both plates were bridged by inactive Ag wire bend with each end resting in agar. No effect was observed on inactive Ag wire in agar. Ag wire bridge was removed and replaced with agar bridge, with no results. Then both agar and Ag wire bridges were used, resulting in activation of inactive Ag wire and production of sterile zone around it. This demonstrated

to them that AgCl produced Ag ions which could be transferred to inactive Ag by electropotential difference through suitably closed electric circuit.

253. PUBLIC HEALTH ASPECTS OF TREATMENT OF WATER WITH SILVER (in English), J. Gibbard, Amer. J. P. H., 27:112 (1937). Stated that from bacteriological point of view, Ag ion is one of most active agents, exceeded only by Hg ion. While working with B. coli at 1,000,000/cc in aq. dest. at 20 C Gibbard found various forms of Ag to be bactericidal thus: 1 ppm Ag as AgNO₃ in 1/2 hour; 1 ppm Ag as Ag₂O in 1/2 hour; 1 ppm Ag as electrically dispersed colloidal Ag in 2 hours; 1 ppm Ag as AgCl in 1 hour. Temperature had marked effect on contact time; at 10 C required 7 hours compared to 1 1/2 hours at 22 C. Believed that high oligo. doses would not produce immediate pathological or physiological effects in human beings.

254. THE CUMASIN METHOD FOR STERILIZATION OF DRINKING WATER (in German), W. Kruse and M. Fischer, Ges. Ing., 60:10 (1937). Method used by Kruse and Fischer was intended for small installations in which only slight amounts of Cl₂ are required. Their method permits electrolytic production of Cl₂ in conjunction with electrolytic production of Ag ions. Their apparatus is simpler than chlorination equipment. Can be run by storage batteries on cars, or by dry cells. Can be applied to entrance pipes of water reservoirs, or to household taps. Operating at 30 to 50 milliamperes and 12 volts can produce 300 to 500 gamma Ag in 10 seconds, enough to disinfect 10 to 20 l water. Household apparatus named "Cuma-Durchfluss-Apparat"; the pocket size named "Cumataucher" (Cuma immerser). The pocket size operated dry cells at 3 volts with 6 milliamperes produced 60 gamma Ag in 10 seconds, enough to disinfect 2 l water with 6 hours' contact. Water, which has insufficient natural chlorides, can be prepared by addition of about 0.05 ppm NaCl. Their "Sina" apparatus, without use of Ag electrodes; they employed Pt electrodes and produced Cl electrolytically.

255. THE USE OF OLIGODYNAMIC ACTION OF SILVER IN THE SANITATION OF WATER (in German), Franz Lieb, Arch. f. Hyg., 119:92 (1937). Summarized previous investigators' findings on activation of metals to make them oligo. Criticized method of evaluating oligo. action of test metal by its action in infected solid media in petri dishes. Results of such tests are conditioned by such uncontrollable factors as purity and surface condition of metal, kind and proportions of colloids and salts in medium, and thickness of medium layer. Lieb concluded that more suitable method for undisturbed oligo. test should comprise use of aq. dest. rather than solid media. His search of practical oligo.

substance was based on criteria that it must be just soluble enough to free Ag ions, yet not be too soluble; and that substance must be available in usable form. He regarded Ag_2SO_4 as too soluble -- $1/69$ at 100°C ; Ag_2S as too little soluble -- 10^{-17} ; but the following had optimum solubility: Ag_2CO_3 , Ag_2O , and AgCl . Of these he chose AgCl as most suitable, capable of being worked into usable shape, of being self-activating, and of retaining its activity during long exposure. Described his method of preparing AgCl rods from AgNO_3 and HCl . Made potentiometric measurements of solubility of AgCl in distilled and various other waters and found results to vary thus; in $\text{M/l} \times 10^{-8}$: aq. dest. 381 at 5 min, 415 at 2 hours, 453 at 24 hours; city tap water 6.6, 2.9, and 2.6 for same time intervals; well water 0.19, 0.25, and 0.31; bath water 0.12, 0.28, and 0.27; and swamp water 0.27, 0.34, and 0.12. In aq. dest., addition of NaCl reduced solubility from 3.8×10^{-6} to 1.3×10^{-7} . Presence of organic matter reduced solubility. To determine bactericidal action of AgCl , used 24-hour cultures of *B. coli*, and various pathogens in bouillon, and added inoculations of these to samples of various water in contact with AgCl . Only *B. coli* showed bactericide in 24 hours, all pathogens including typhi, and dysent. had their numbers greatly reduced. No better results were obtained after 48 hours' contact (the test data do not show AgCl dose). Found bacteria native to water to be quite resistant to AgCl and Katadyn-Ag. Cultured *B. coli* were very sensitive to Ag, but resistance of those found in natural waters approximated that of water-native bacteria. He concluded that strict sterilization of water by Ag is not possible, but it is possible to kill pathogens, especially intestinal germs. Application of AgCl should not be indiscriminate. It is lasting and useful disinfectant of pathogens.

256. A BACTERIOLOGICAL SURVEY OF A SWIMMING POOL TREATED WITH SILVER (in English), W. L. Mallman, Mich. Eng. Exp. Sta. Bul., Vol. 12, No. 5 (1937). Examined operation of Electro-catadyn set installed for pool near E. Lansing, Michigan, with volume of 36750 gallons, flow of 150 gpm and turnover of $5\frac{1}{2}$ hours. Other equipment consisted of pressure filter, alum doser, hair-catcher, and hand-controlled chlorinator. Examinations comprised counts of total bacteria at 37°C , and determination of *B. coli* and Strept. indices. Weekly samples over 1 year with chlorination showed average 0.31 *B. coli* and 0.92 Strept. After starting Electro-catadyn, samples taken twice weekly for 3 weeks. During that time, bacteria counts increased from 0 to 205,000/cc, *B. coli* remained negative, and Strept. varied from all negative to 3 negatives out of 3 samples. Judged on basis of A.P.H.A. standards, all samples showed unsatisfactory bacteria count, but all *B. coli* indices passed. The Ag-resistant bacteria were identified as *Alcaligenes Bookerii*, *Sarc. lut.*, and *Micro. aurantiaca*, which he

said were not disease producers, had no relation to pollution by bathers, and were common air and water bacteria. He found bactericide by Ag thus: on *B. coli* 1333 gamma/l in 10 minutes, 666 gamma in 30 minutes, 266 gamma in 30 minutes; for *Eberth. typhi.*, 266 gamma in 5 minutes. He concluded that Ag was unsatisfactory for pools.

257. INVESTIGATIONS ON THE PHYSIOLOGICAL ACTION OF HIGHLY KATADYNIZED WATER (in Italian), Eloisa Milla, An. d'ig., 47:325 (1937). Reviewed work of previous investigators. Made tests on albino rats, by feeding them water containing 2.0 ppm Ag. Each consumed daily about 50 gamma Ag per 100 g of body weight, which corresponded to a daily dose for humans amounting to 37 mg/100 kg. This was much in excess of amount which human could introduce into his system in any manner. Rats remained healthy and lively, all functions were satisfactory; showed no browning of ocular membranes nor of visible mucosae. Autopsies on rats revealed no abnormality of internal organs, or presence of granules in kidneys.

258. FURTHER BIOLOGICAL INVESTIGATIONS WITH IRRADIATED METAL COMPOUNDS (in German), Oskar Reid, Wien. Med. Wochs., 87:1246 (1937). Fe irradiated by ultra-violet in presence of fats became activated furthering growth of *Phaseolus vulgaris* L. Fats irradiated in presence of ZnO_2 , $CuSO_4$, or CuS , also became active.

259. AN INVESTIGATION OF THE KATADYN TREATMENT OF WATER WITH PARTICULAR REFERENCE TO SWIMMING POOLS (in English) Robert Shapiro and Frank E. Hale, N.E.W.W.A.J., 51:113 (1937). Shapiro and Hale examined performance of Electro-Katadyn hand set. In Catskill tap water with 0.2 ppm Ag they sterilized 98 *B. coli*/cc in 33 minutes. A dose of 0.3 ppm produced turbidity of 1 ppm, but was unnecessarily high for disinfection. Water with 0.3 ppm Ag after 24 hours contained enough residual to sterilize *B. coli* in 30 minutes' contact. Six days later the same water reduced *B. coli* to 1 positive in 10 cc in 30 minutes; the long-time residual characteristic was thus demonstrated. Swimming pool water was sterilized in 40 minutes with Ag doses down to 0.03 ppm, both for *B. coli* and total bacteria counts. Ag had no effect in salt water. Presence of ammonia or its salts inhibited oligo. action. Addition of alum and filtration after adding Ag reduced turbidity caused by Ag, but enough Ag was left in filtrate to provide sterility in 30 minutes. Larger Electro-Katadyn set was set up at Brooklyn swimming pool. Water was recirculated, treated with alum, sand-filtered, then treated by Electro-Katadyn. Examinations were made from January through June 1935, and 183 samples were taken. *B. coli* were preponderantly negative, but bacteria counts were not affected; they revealed presence of *Staph. alba* and *aureus*, and *Strept.*, which may be important in eye, ear, nose,

and throat infections; although Ag may produce effective sterilization with 2 hours' contact -- impractical for swimming pools.

260. THE EFFECT OF SILVER-IONS ON SOME ENZYMES OF BACTERIUM COLI (in English), John Yudkin, *Enzym.*, 2:167 (1937). The B. coli were grown in inorganic medium with 0.5 percent glucose, washed twice, and suspended in aq. dest. Then treated with varying amounts of Ag_2SO_4 , and activities of enzymes measured with various known techniques after bacteria contacted 2 hours.

(1) Glucose dehydrogenase: smallest doses of Ag promoted action increase up to 40 percent of original, further increase in dose first caused gradual inhibition to 20 to 30 percent of original activity, then followed sudden and precipitate decrease in activity. (2) Succinic dehydrogenase: with increasing Ag doses, first appeared slight inhibition, then marked activation, then gradually greater inhibition. Some tests showed maximum activity twice the original. (3) Lactic dehydrogenase: no increase in activity, but steadily increasing inhibition. (4) Formic dehydrogenase: activity was unaffected until high Ag concentration was reached, probably 10 times that required for glucose dehydrogenase. Amount of Ag required for inactivating enzymes with bacteria in organic media was 5 to 10 times amount required by bacteria in inorganic media. To test for amount of Ag removed by B. coli, contacted them 2 hours with varying amounts of Ag_2SO_4 , centrifuged, added substrate to fresh bacterial suspensions, after 2 hours' contact tested activity of their glucose dehydrogenase. For bacteria in inorganic media the $\text{N}/10^4$ silver was completely removed by bacteria, an amount 10 times that required for complete inhibition of glucose dehydrogenase. With treatment by $4\text{N}/10^4$ enough Ag remained to inhibit glucose dehydrogenase activity 75 percent. Complete inhibition of enzyme occurred with 3 to 4×10^7 Ag ions per bacterium. Washing B. coli 3 times with aq. dest. did not revive them from Ag poisoning. Cited work by others: H_2S reactivated saccharase and crystalline urease poisoned by Ag; Takadiastase poisoned by Ag unaffected by cyanide but only partly reversed by other agents; anti-staph. bacteriophages poisoned by HgCl_2 were revived by H_2S , inactivated by KCN and revived by AgNO_3 . Yudkin could not revive lactic dehydrogenase by any of agents NaCl , $\text{Na}_4\text{P}_2\text{O}_7$, H_2S , $\text{Na}_2\text{S}_2\text{O}_3$, or KCN. KCN almost completely restored glucose and succinic. H_2S poisoned succinic. B. coli suspension cultured in inorganic medium contacted with $\text{N}/10^6$ of Ag_2SO_4 or 1.6×10^5 Ag ions per bacterium left only 0.00001 percent alive but had no observable effect on glucose, lactic, succinic, or formic dehydrogenases; thus, bacteria can be killed by Ag before any investigated enzymes are appreciably influenced. He stated that dissociation of viability and enzyme action in opposite sense has also been noted, that is, inhibition of enzyme without impairing growth.

261. MECHANISM OF THE BACTERICIDAL PROPERTIES OF SILVER (in English), Stuart Mudd and E. J. Czarnetsky, A.S.P.R.P. Prog. Reps., Vol. 3, Ap. 3, (Aug 9, 1937). Mudd and Czarnetsky at the University of Pennsylvania on a research project sponsored by the American Silver Producers submitted report they received from Germany (probably from Katadyn company) dealing with action of Katadyn-Ag. Nothing new was presented. No other work was undertaken by these fellows of this research project.

262. BACTERICIDAL PROPERTIES OF SILVER (in English), Czarnetsky and Nielsen, A.S.P.R.P. Prog. Reps., 4:89 (Nov. 1, 1937). Czarnetsky proposed to employ hemolytic Strept. for determining where Ag acts on bacteria. Nielsen reported that those Ag salts which were soluble to 1 ppm of Ag completely inhibited fungus spore germination. Ag_2O and AgCN in greater dilutions (0.1 ppm) gave indications of being more toxic than other salts.

263. TOLERATION AND SENSITIZATION OF MICROORGANISMS BY THE OLIGODYNAMY OF METALS AT A DISTANCE (in French), Alberto Bertuzzi, Bul. Soc. Chim. Biol., 20:382 (1938). In slide 5 to 6 mm thick Bertuzzi hollowed out center 3 to 4 mm deep, placed strip of Pb in bottom of hollow, covered hollow with slide, and thereon placed drop of infusion with Infusoria Holotrichide; Holo. were immobilized, but not killed, by caffeine, then all was sealed up with vaseline. After some time he observed marked vacuoles in cytoplasm which grew until cell was entirely filled by 2 to 5 large vacuoles disposed around periphery, pressing on membranes, distorting and bulging them until cells finally exploded, rapidly dissociated, and disappeared in liquid. Control not exposed to metal was not affected. Cells removed from vicinity of Pb immediately upon appearance of vacuoles began to return to normal after some hours, and were fully normal in few days. Those not hermetically sealed but exposed to Pb, resisted action.

264. EFFECT ON THE OLIGODYNAMIC ANTI-BACTERIAL PROPERTIES OF SILVER IRRADIATED BY ULTRA-VIOLET RAYS (in Italian), Augusto Bruno, An. d'ig., 48:733 (1938). Solid Ag vessels of 200-cc capacity irradiated by "Actinia 31" ultra-violet lamp at 20-cm distance for 15 minutes to 1 hour. Natural water bacteria at 500 to 1000/cc placed in water in Ag vessel of 15 minutes irradiation, were dead in 1/2 to 1 hour later, while those in non-irradiated but oligo.-active Ag vessel were not dead in 48 hours. Bactericide was determined by plating in agar or gelatin. Water with 200 bacteria/cc after 24 hours in non-irradiated but oligo.-active Ag vessel showed 87/cc; after 7 days in petri dish, counted 3000/cc. Then water with 3000 bacteria/cc kept 24 hours in irradiated Ag vessel and after 2 days in petri dish showed complete sterility. Water artificially infected with about 400,000 B. coli/

cc in non-irradiated Ag vessels, bacterioide was faster than on water bacteria of preceding tests; but in irradiated Ag-vessels *B. coli* were almost indifferent to compounded oligo. action, whereas water bacteria were very sensitive. Same result was noted for *Vib. cholera*. However, no *B. coli* or *Vib. cholera* showed growth stimulation in any case. In glass, Ag piece was bactericidal to pathogens, and increasingly so after exposure to ultra-violet or sun rays. Concluded that ultra-violet rays increases oligo. lethal action against bacteria otherwise less sensitive to Ag, but lessens the action against those strongly sensitive to Ag -- the pathogens.

265. SILVER ION AND AMMONIATED SILVER ION (in English), W. E. Caldwell, W. B. Bollen, F. W. Bird, and G. F. Olsen, *A. W. A. J.*, 30:131 (1938). Investigated action of Ag salts on chlorinated swimming pool water contaminated with *E. coli*, *P. aerugin*, and *B. subtilis*. Adding 0.15 ppm AgNO_3 darkened pool water immediately; resulting photo-chemical action produced local concentrations of semi-colloidal clouds of AgCl . Plate count dropped from 15,000 to 340 in 1/2 hour, and to 200 in 3 1/2 hours; however, Ag ion concentration began to decrease by photo-chemical loss and plate count began to increase. No colon-aerogenes were found, while *P. aerugin*. predominated in plates. Then to pool added AgNO_3 in 10 times the amount of NH_4OH required to form ammoniated-Ag ions. Plate and coliform group counts remained at zero during more than a week of subsequent testing, and no darkening of pool water appeared. Chlorination was then discontinued in pool opened to bathers. Average Ag ion dose during next 18 days was 0.05 ppm. At that time bacteria count suddenly became excessive, although at no time was coliform test positive.

266. BACTERIOLOGICAL AND HYGIENIC RESULTS FROM INVESTIGATIONS OF DISINFECTION WITH KATADYN METHODS (in German), Silvio Hoffmann, *Arch. f. Hyg.*, 120:147 (1938). Worked with Zurich tap water containing 5 ppm chlorides, and with aq. dest. Compared action of Elektro-Katadyn with AgNO_3 . Indication of survival of bacteria in gelatin plates was noted after 17 days at 22 C, and in agar plates after 9 days. *B. coli* from fresh faeces at 1 1/2 to 2 million/cc were disinfected equally as rapid for like amounts of Ag ions in AgNO_3 or from Elektro-Katadyn; sterility was produced by 0.25 ppm Ag with 3 hours' contact. With *B. coli* at 800,000/cc and with 0.1 ppm Ag 10 strains of 6- to 20-year old culture *B. coli* were sterilized in 2 hours while 10 strains isolated from fresh faeces were sterilized in 3 hours. Freshly isolated *B. coli* treated with 0.1 ppm Ag ions with 3 hours' contact were reduced 94 percent from 20,000,000/cc, and completely sterilized from 10,000/cc. *Micro. pyogen. aureus*, with same treatment, reduced 95 percent from initial 2,000,000 and 98 percent from initial

50,000/cc. In all cases, freshly isolated bacteria were more resistant than long cultured. For *Micro. pyogen. aureus* fresh from pus at 85,000 to 300,000/cc treated with 0.15 ppm Ag ions with 3-hour contact, reduction was 94 percent; addition of 0.1 percent urine gave only 40 percent reduction. With 0.4 ppm Ag ions, 0.1 percent urine gave bacterial reduction of 89 percent against 97 percent without urine. Analogous results were observed with *B. coli*. Small amounts of peptone, or blood-serum inhibited oligo. action of Ag. Their work attempting to determine bacteriostatic and bactericidal doses of Ag was not conclusive because of heavy absorption of Ag by nutrient media, which they reported.

267. ON THE DISINFECTION OF SMALL VOLUMES OF WATER BY THE ELEKTRO-KATADYN METHOD (in German), Silvio Hoffmann, *Schw. Med. Wochs.*, 68:1278 (1938). Performed 48 test series with pocket-size Elektro-Katadyn on water infected with 200,000 to 300,000/cc of various bacteria, contacted 3 minutes by apparatus, then further contact by activated water. All coli-typhi.-dysent. bacteria were sterilized in 2 to 3 hours. *B. anthracis* spores were reduced to 88/cc in 1/2 hour and 73 in 3 hours. All foregoing were produced with 0.185 to 0.21 ppm Ag. After 5 months' storage in dark, such activated water contained 0.15 to 0.19 ppm Ag. Observed no difference in Ag action on filtered water from 11 wells, 3 from lake, 2 from tap, and 3 from river.

268. OLIGODYNAMY IN THEORY AND PRACTICE (in German), M. Hosenfeld, *Chem. Ztg.*, 62:3, 20 (1938). On basis of his review of existing literature Hosenfeld concluded that oligo. sterilization could be applied in practice only to limited extent. Action is inhibited by presence of suspended matter or SO_4 . Chloride content of over 500 ppm requires long contact period.

269. THE BACTERICIDAL EFFECT OF THE METALLIC ORIGODYNAMY TOWARD THE BACILLI IN WATER (English abstract from Japanese), Y. Ikegami, *Nav. Med. Assn. Jap. Bul.*, 27:29 No. 5 (May 1938). "Shofu Origodyn," 1.6 cm long x 1.5 cm diameter had powerful bactericidal effect depending upon number of bacteria, temperature, contact time, active surface, etc. Bactericide was inhibited by organic substances or dissolved salts; almost completely by such proteins as blood-serum.

270. BACTERICIDAL ACTION OF SILVER-SALTS (in English), Charles A. Zittle, *A. S. P. R. P. Prog. Reps.*, Vol. 5, Ap. I (Mar 1, 1938). In order to determine whether Ag kills beta-hemolytic *Strept.* by combining with labile antigen (LA) on its surface, Zittle observed action of Ag salts on these bacteria with and without LA added. Very little factual data presented. Concluded that according to work done so far, hemolytic *Strept.*

destruction by Ag did not take place at LA molecule, nor could it be called physiochemical. By electro-dialysis of horse serum treated by Ag he concluded that compounds are formed between Ag and proteins that cannot be broken down by washing with water or by electrodialysis.

271. INVESTIGATIONS OF ELECTRO-CATADYN STERILIZATION OF WATER IN FIUGGI BATHING POOL (in Italian), A. Alessandrini and G. Labranca, An. d'ig., 49:201 (1939). Alessandrini and Labranca studied operation of Electro-catadyn sterilizer at Hotel Palazzo della Fonte at Fiuggi, Italy, for their outdoor pool of 800 m³. Water recirculated to give 1 turnover in 12 hours, first to pre-filter, dosed with alum, to pressure filter, then through Electro-catadyn dosed with 0.15 ppm Ag. Raw water with 120 bacteria colonies per cc in gelatin and 4/cc in agar; after treatment with Ag, and with many bathers, pool water showed 44/cc in gelatin and 24 per cc in agar, while with few bathers water indicated 14/cc in gelatin and 7/cc in agar. After Ag treatment was absent for 7 days, pool water, with few bathers, showed 16/cc in gelatin and 12/cc in agar. Raw water samples and all pool water samples showed no B. coli positives for 50 cc and no anaerobes for 20 cc. They did observe colonies of chromogenes, water-native aerobes, and sporogens in plates. They concluded that this method, although not complete sterilizer, was improvement over other methods, because of its long-time residual and non-production of odors and tastes.

272. ON THE PHYSIOLOGIC IMPORTANCE OF MANGANESE AND OTHER ELEMENTS FORMING TRACE CONSTITUENTS IN ORGANISMS (in French), Gabriel Bertrand, Erg. Vitm. Hormf., 2:192 (1929). In 1897 he concluded that Mn is physiological element necessary for catalyzing intracellular chemical transformations in plants and animals. He worked with Asperg. niger and found 0.01 ppm of Mn highly stimulating to growth, and 0.1 ppm completely inhibitive. Following metals have been found occasionally as traces in organisms: Li, Cr, Rb, Sr, Ag, Cs, Al, Ti, As, Mo, Sn, and Pb. Oligo. metals present acted as catalysts.

273. ARGYRIA, THE PHARMACOLOGY OF SILVER (book in English), W. R. Hill and D. M. Pillsbury, Waverly Press, William and Wilkins, Baltimore, Md. (1940). They stated that there is abundant experimental and clinical evidence to indicate that any form of Ag taken by mouth, or otherwise reaching stomach, will produce deposits of Ag in various organs of body if such ingestion is continued for sufficient length of time. Experimental background for theories of nature and mechanics of absorption of Ag compounds is unconvincing. No adequate studies of Ag balance, ratio of Ag absorbed to Ag ingested, have been made. It has been stated that greatest portion passes out unabsorbed. One case displayed

discoloration of skin 5 days after administering 17.5 g AgNO_3 by stomach tube. It cannot be stated whether or not Ag absorption is more rapid with large doses over short time or vice versa; or what relative absorption of various salts is; or effect of physiological or anatomical changes in intestinal tract. Ag deposition produces no pathological alterations other than discoloration.

274. INJURIES FROM CHLORINATED WATER AND THEIR ELIMINATION BY SILVER (CUMASIN METHOD) (in German), W. Kruse, Arch. f. Hyg., 122:177 (1939). Kruse referred to the objections raised to his new sterilization method as he stated, ". . . it is now enjoying well-known fate of most new ideas, dominance of sweet tradition, which so happily satisfies itself with old, safe methods." Spoke of general desirability of finding substitute disinfectant of swimming pool water for chlorination. Both Ag and Cl_2 are equally retarded by presence of turbidity, dissolved and organic matter in water. On basis of contact time required for bactericide, Cl_2 is preferable to Ag. However, Kruse cited H. Selter (Ztbl. alg. Gesundheitspflege 1913, p 241), to show that with calcium hypochlorite 4 to 6 hours' contact was required, which is no better than contact time for Ag. Operation of Cumasin system at Leipzig pool, during 1931 and 32, after Ag dosing was stabilized at 50 gamma/l, was inspected, and 6000 bacteriological examinations were made. Never found *B. coli* positive in 1 and 10 cc, rarely in 100 cc of Ag-treated pool water. Artificial infections of such water with large numbers of *B. coli* were sterilized after 6 hours' contact. Bacteria counts also greatly reduced. In 1937, examinations showed similar results; thus maintained good record of operation over 7-year period. Maintained that Ag-resistant water bacteria are harmless, and that their counts have no relation to bather population. Evaluation of disinfection should be based on *B. coli* index. Bacteria counts are unreliable since they fluctuate greatly without reason from day to day and from test to test in same day, while *B. coli* remain continuously absent; therefore bacteria counts can have no importance from hygienic standpoint. Of 546 samples from 7 chlorinated pools during 5 years, 13.3 percent showed less than 0.1 ppm residual Cl_2 with bacteria counts over 200, often over 10,000 cc; 17 showed *B. coli* present. From other pools with "well-chlorinated" water, 7 percent of 550 samples with 0.5 ppm residual Cl_2 showed bacteria 200 to 180,000/cc, and 2 positives of *B. coli*. Examinations of 2 chlorinated pools in Gelsenkirchen bacterial counts increased with increasing Cl_2 residual; *B. coli* decreased, thus; 7 tests with lowest Cl_2 residual bacteria counts averaged 630/cc, ranging from 50 to 3250/cc; 4 samples with highest Cl_2 residual average count 2700/cc ranging from 110 to 6750/cc. Remy, examining chlorinated water from Marienbad at Freiberg, found large bacterial growth in gelatine plates beginning after third day, for waters

that had chlorine residuals from 0.13 to 0.25 ppm. Concluded that 2-day count cannot be relied on for proper evaluation of swimming pool sterilization. Observed that Ag at 10 gamma/l was definitely active against algae.

275. BIOLOGICAL ACTION OF METALS AT A DISTANCE (in Spanish), A. E. Roffo, Jr., Bol. Inst. Med. Exp. Cancer, 16:55 (1939). Reviewed work of previous investigators of telergy of metals, beginning with Elfving, 1890 (q. v. supra). Cited work of V. Rivera who in 1930 observed activity on plants encased in thick-walled Pb boxes and attributed this to secondary rays from Pb set up by action of cosmic rays. Roffo investigated action of various metals 1 to 2 mm distant from cultures of normal and neoplastic fibroblasts of tissues. From 16 experiments involving 384 cultures found inhibitions of culture development, in no relation to atomic weight of test metals. Strongly inhibitive were Hg, La, Mg, and Be on normal tissues; and on neoplasts were Be, Mg, Fe, Sn, La, W, Hg, and Pb.

276. OFFICIAL DISTILLED WATER: PHYSICO-CHEMICAL ANALYSIS AND THE IMPORTANCE OF ITS BACTERIOLOGICAL EXAMINATION (in French), Auguste Sartory, Jacques Meyer, and Francois Fischer, Bul. Sci. Pharm., 46:49 (1939). They examined water distilled by all metal still, all pyrex still without access to atmosphere, all pyrex with access to atmosphere, and by electro-osmosis. The pH of distillates varied from 5.25 to 7.0; conductivity from 15×10^{-6} to 108.13×10^{-6} , with highest conductivity from metal still. Cu ran 2.6 ppm from metal still, 0.1 ppm from all pyrex sealed, 0.05 ppm from atmospheric pyrex still; and 0.15 from electro-osmotic apparatus. Pb was found in none. Boron was 0.1 ppm for sealed pyrex still but absent from others. Aq. dest. stored in stoppered hard or soft glass bottles showed certain quantities of electrolytes. Concluded that aq. dest. best stored in Jena or pyrex glass at pH 5.5 or thereabouts. Cited results of examinations by P. T. Müller on aq. dest. obtained from pharmacies, and from laboratory of Inst. of Hygiene at Graz. Of 16 samples only 2 showed less bacteria than 100,000/cc; all others ranged from 600,000 to 6,000,000/cc.

277. OBSERVATIONS ON BACTERIAL GROWTH IN PRESENCE OF SILVER FOIL (in English), C. Siebenmann, Amer. J. Hyg., 29: 36 (1939). Placed Ag foil in nutrient medium inoculated with 18 different pathogens. Growth was not inhibited by bright-surfaced Ag. Attributed this to reaction of substances in medium with Ag, preventing its oligo. activity.

278. REMARKS ON THE APPLICATION OF THE PRINCIPLE OF OLIGO-DYNAMIC ACTIVITY OF SILVER TO FILTER CANDLES (in Italian),

E. Fiori, An. d'ig., 50:408 (1940). Fiori determined that ordinary filter candles adsorbed Ag ions destroying oligo. action. This difficulty was eliminated by impregnating candles with oligo. Ag.

279. THE INHIBITORY ACTION OF POTASSIUM TELLURITE ON COLIFORM BACTERIA (in English), Alexander Fleming and M. Y. Young, J. Path. and Bact., 51:29 (1940). Various bacteria were inoculated in nutrient broth and agar containing various concentrations of K_2TeO_3 and incubated at 37 C. Of 16 strains of *B. coli*, 9 were completely inhibited with 0.5 ppm K_2TeO_3 , 15 inhibited at 4.0 ppm, and one grew with 100 ppm. Of 302 strains of *B. typhi*, paraty.-A and *B. salmonellae*, dysents., etc., 78 percent were inhibited by 1.0 ppm, 12 percent grew with 20 ppm. *B. typhi* and paraty. were more sensitive than others, dysents. were least. They observed that sensitivity of *B. coli* not correlated with biochemical activity or antigenic specificity. Observed that sensitive strains became more resistant to tellurite when in presence of resistant strains. They thought that resistant bacteria absorbed enough metal to reduce metal content in medium to the point where it became harmless for sensitive bacteria.

280. OLIGODYNAMIC EFFECT OF SILVER (in English), by A. Goetz, R. L. Tracey, and F. S. Harris, Jr., in Silver in Industry, a book by Laurence Addicks, pp 401-429 (1940). Thoroughly reviewed work of previous investigators. Believed simplest method is activating Ag-crystal surfaces by heating in air or C. thereby creating oligo. source in form of surface layer of oxide of certain solubility, and producing Ag ions by dissociation in its surrounding medium. Activating substance can be deposited chemically or electro-chemically. Most Ag compounds are soluble enough for bactericide except Ag_2S . With purely chemical activation, activity depends upon solubility of surface Ag compound. Electric method can produce greater Ag ion concentrations in water than can any Ag compound. However, such solutions can be metastable, evidenced by occasional blue or brown coloration and indicating Ag colloidal dispersion. This method has practical advantage of producing Ag ions without introduction of deleterious anions. They found that for 60 minutes' contact, minimum lethal concentration of Ag for *E. coli* at 40 C was 30 to 40 percent lower than at 25 C. Maximum resistance was at pH 7.0 to 8.0. Minimum doses were found at pH 9.0 and pH 6.0, thus indicating disinfection by Ag favored by either acid or alkaline conditions. Minimum lethal dose depended upon nature of substrate as well as upon nature and concentration of microorganisms. Spores were extremely resistant, but their vegetative forms were not. For *E. coli*, rate of disinfection varied with contact period and concentration of Ag ions. Above 0.13 ppm bactericide rate varies very little. Only one

Ag ion required to kill bacterium but high Ag ion adsorptive capacity of bacterial surfaces can shield other cells. Observed variable resistance of bacteria, also their tolerating capacity. Described Katadyn and Matzka processes.

281. EXPERIMENTAL INVESTIGATIONS ON SILVERED SELF-STERILIZING PORCELAIN FILTERS (in Italian), I. Peragallo, An. d'ig., 50:113 (1940). Filled interior of ceramic filter candles with Ag-covered sand, intending thereby to sterilize any germs passing through filter wall. Not satisfactory because contact time too short and sand grains too large. Ag-impregnated filter candle provided about 100 cm² of Ag surface. Water passed over this surface in capillary streams, facilitating bactericide. Action of Ag-impregnated candle was compared with non-Ag candle in parallel, filtering water inoculated with bacteria 10,000 to 20,000/cc. Test cultures were made in broth and in agar, incubated at 38 to 39 C, then confirmed on endoagar. For *Eb. typhi*. Ag-filter showed negative after 9 days' filtration, but were positive with non-Ag-filter after 3 days of filtering. Same results observed for *B. coli*. Concluded that Ag-impregnated filter candles could sterilize pathogens, but not enough contact time to provide Ag residual.

282. CONTRIBUTION TO THE STUDY OF THE BACTERICIDAL ACTION OF A CATADYN-ACTIVATED WATER ON *B. COLI* (in Italian), Alessandro Ruocco, Gior. Med. Mil., 88:296 (1940). Ruocco was concerned with practical application of catadyn sterilization to tropical water supply. Worked with new electro-catadyn apparatus "Som 500M" of Soc. An. Robinetterie Riunite di Milano, containing 2 Ag electrodes. Water first filtered through candles under pressure. For sterilizing 500 l/hour used 38-milliamperes current from dry cells. Used Florence city water of 0.2 ppm O₂ demand, 257 ppm total hardness, 43 ppm chloride ions, 56 ppm S ions, 86 ppm Ca ions, 10 ppm Mg ions, trace of Fe. Raw and treated water inoculated with various concentrations of freshly isolated *B. coli*. from 48-hour agar cultures, test samples plated, incubated 24 hours at 37 C, then colonies counted. (1) For *B. coli* at 10,000 per cc: filtered but no catadyn treatment, showed 130/cc after 24 hours; catadynized at 30 milliamperes showed *B. coli* 40/cc after 6 hours, zero at 24 hours; with 80 m-A, 11 in 6 hours, zero at 24 hours. Attributed bacterial reduction in filter to 2 bodies therein not explained in equipment literature. (2) *B. coli* at 5000/cc added to water 24 hours after Ag-activation; for 38 m-A, 18/cc after 6 hours, sterile at 24 hours; for 80 m-A, 10/cc after 6 hours, sterile in 24 hours. (3) *B. coli* at 10,000/cc added to water 48 hours after Ag-activation for 38 m-A, 161/cc after 6 hours, sterile at 24 hours; for 80 m-A, 113/cc after 6 hours, sterile after 24 hours.

283. REMARKS ON THE DISINFECTION OF WATER OF THE FIUGGI SWIMMING POOL BY THE ELECTRO-KATADYN METHOD (in Italian), E. Frongia and I. Napoli, *An. d'ig.*, 51:94 (1941). Gave results of their examinations over period August 1937 through August 1939. Poor maintenance and operation of pool equipment and variations in electric current tension, with bad filtration, impaired optimum performance of Electro-Katadyn sterilization. At no time was *B. coli* positive in 50 cc, or anaerobes in 20 cc. Hygienic discipline of pool was very bad, resulting in high N compounds. Not possible to have pool sterilization by Ag entirely automatic; amount of Ag going into solution depends upon conductivity and pH of water, and presence of Fe or H_2S ; all these factors always varying. Therefore, there can be no correspondence between intensity of electric current to Electro-Katadyn and amount of Ag ion actually going into solution. For proper control, constant bacteriological examination is necessary.

284. THE SELF-STERILIZING MANGANATE-SILVERED FILTER CANDLES UNDER PARTICULAR CONDITIONS OF SOME PRACTICAL APPLICATIONS (in Italian), Italo Peragallo, *An. d'ig.*, 51:523 (1941). Upon request of military authorities Peragallo investigated effect of H_2S on oligo. action of Ag. With Electro-catadyn the H_2S combines with Ag ions impeding oligo. This difficulty is eliminated by aerating water before filtering with Ag-impregnated filter candles. H_2S removes Ag residual in filtrate, although his tests always showed such filtrates sterile, even with 9 days' use of candle. Assumed that H_2S attacked Ag on exterior surface of candle leaving interior Ag active. Using water saturated with H_2S , Ag-impregnated candles became inactive only after 18 days' continuous filtration; were then easily regenerated. Stated that in 1935 German investigators observed that thorough shaking of Ag metal in $KMnO_4$ caused reaction to Ag_2O and reduction of permanganate resulting in compound $Ag_2O \cdot 2MnO_2$ on Ag surface. They demonstrated that such prepared Ag after repeated immersion in saturated H_2S vapor maintained its full oligo. bactericidal power against usual test bacteria, while control Ag without $KMnO_4$ treatment was entirely inactivated by H_2S , even though subsequently treated with H_2O_2 , which is oligo. activator of Ag. Peragallo treated Ag-impregnated candles with permanganate. With H_2S water they produced complete sterility, while non-permanganate candles showed profuse growth of *B. coli* in filtrate of same water. No diminution of activity of permanganate-Ag candles was observed after 64 hours' operation and 450 l throughout; was still active after 3 months' operation. Concluded that treatment of Ag with $KMnO_4$ solved problem of inhibition of oligo. action by H_2S . It conserved oligo. action in both filter candle and filtrate. He surrounded such permanganate-Ag impregnated diatomaceous earth filter candle with a porous kaolin prefilter element and enclosed

them in case with suitable fittings. Prefilter did not impair sterilization of permanganate-Ag element, but rather enhanced activity by removing suspended material and some bacteria from sterilizing element.

285. SELF-STERILIZING SURFACES (in English), A. Goetz, R. Tracey, and S. Goetz, Science, 95:537 (1942). Maintained that bactericide by Ag ions in water is matter of hours, whereas that by contact of bacteria with surfaces having Ag is matter of minutes. Developed coating by colloidal dispersion of Ag compounds in resins, adding stabilizing or plasticizing substances and opaque neutral filler. Resultant compound is varnish-like, viscous fluid which can be applied by brush, spray, or impregnation to various bases like plastics, glass, wood, paper, cloth, etc. Hardened in place by polymerization or evaporation. Surfaces are tasteless, odorless, resist mechanical wear and chemical attack of weak acid or alkali solutions, or of boiling water. Amount of Ag in surface varied with requirements. Atomic Ag exposes at the surface only small fraction of its total Ag content. This is in form almost insoluble in water but available to proteins. Unexposed supply is protected against chemical attack; replacement occurs by diffusion. Tested films of infected media spread on self-sterilizing surfaces. *E. Coli* at 10^8 /cc were sterilized in less than 1 minute. Bacterial concentration did not influence bactericidal rate. Mold suspensions containing high concentrations of spores were readily sterilized in all suspending media, except in nutrient broth or milk. Reduced spores of *B. subtilis* 97 percent with 15 to 30 minutes' exposure. Activity of surfaces remained unimpaired over 2-month period with 30,000 contacts.

286. EFFECT OF OXIDATION-REDUCTION ON GERMICIDAL EFFICIENCY OF SOME METALLIC SALTS (in English), Howard L. Guest and A. J. Salle, Proc. Soc. Exp. Biol. and Med., 51:272 (1942). Investigated effect of germicide on *Staph. aureus* of various salts of Fe, Sn, Mn, Ag, and Hg, alone and in combinations. In every case, mixture of 2 salts, one in higher state of oxidation than other resulted in increased germicidal action. Combined effect was greater than sum of individual effects. Such increased germicide depends upon existence of oxidation-reduction system; it is function of positive ion only.

287. THE INACTIVATION OF FUMARASE BY METAL IONS (in German), K. Laki, Zts. Phys. Chem., 273:248 (1942). Used isolated crystalline fumarase. Observed that deactivation by heat showed same monomolecular reaction as in denaturing of proteins by heat. Same was observed with inactivating by CuSO_4 and HgCl_2 . However, inactivation by FeCl_3 and AgNO_3 was of different nature, not

monomolecular. Concluded that Fe and Ag ions are easily reduced and oxidize enzyme at S-H group, a particularly sensitive place. Could not explain actions of Cu and Hg; thought these similar to protein denaturation by heat.

288. OLIGODYNAMY OF SILVER -- A STUDY OF SOME VARIABLES (in Spanish), Osvaldo M. Repetto and Fernando Modern, Rev. Inst. Bact., 11:243 (1942). Studied influence of diverse factors on oligo. action of Ag using E. coli in normal horse serum and albumin from same. Both inhibited oligo. of Ag. With 1-hour contact bacteriostatic Ag ion dose for E. coli at 600/cc was $N/10^6$, and with E. coli at 3×10^9 /cc was $N/10^3$.

289. SILVERSAND, A FILTER MATERIAL TO MAKE HARMFUL BACTERIA INACTIVE IN WATER (in English), Sales pamphlet of Whyt-Rox Chemical Co., Wauwatosa, Wis. (Received by Office, Chief of Engineers 22 June 1942.) Filter material termed "Super-Ionite" is granular synthetic material, of zeolite nature, containing Ag. Granular carrier acts as activating agent. Sterilization is produced with 10 to 15 minutes' contact period. Material is used in form of filter beds, most effectively as safety follow-up treatment for pre-filtered and dechlorinated water. Material acts by desorption of Ag ions by bacteria when they contact material by being adsorbed thereon. No appreciable Ag ion concentration is imparted to water.

290. WATER SANITATION WITH SILVER (in English), Alexander Goetz, A. W. W. A. J., 35:579 (1943). Ag is germicidal only if in contact with cell surface and in ionic state. Bright or tarnished Ag surface is neutral. Chemically unclean (slightly oxidized or halogenized) surfaces are highly active. Ag surfaces freshly cleaned or abraded are somewhat active and become inactive within 1 hour. Ag ions adsorbed by cell surface then form Ag proteinates, irreversibly, and cause death. Bactericidal efficiency varies with bacteriological and chemical conditions and with method of application. Lethal dose of Ag varies from 0.02 to 1.0 ppm, although Goetz found that for water heavily contaminated with usual pathogens only 0.2 to 0.6 ppm Ag is required. Use of Ag salts impractical because of formation of local high Ag ion concentrations, and because of darkening caused by reduction to colloidal Ag by light. Believed Krause and Matzka methods better. Interferences to Ag sterilization by suspended matter can be avoided by pre-settling or pre-filtering. Ag compounds with anions found in water -- SO_4 , Cl, CO_3 , NO_3 , PO_3 -- have solubility products higher than Ag-protein compounds; thus, water anions do not interfere with bactericide of Ag. S reduces efficiency of Ag. The cations Ca, Mg, Na, K, Fe, and Si are non-interfering. Ag sterilization is independent of pH. NH_4 could form $Ag(NH_3)_2$ which is non-active. Ag provides long-term residuals.

291. EXPERIMENTAL CONTRIBUTIONS TO OLIGODYNAMIC ACTION, WITH SPECIAL REFERENCE TO WATER SANITATION (in German), Otto Ornstein, Acta. Path. Micr. Scand., 20:86 (1943). Important factors in application of oligo. to water treatment are consideration of composition of raw water, entire treatment process, and distribution system. Investigated action of I_2 , $CuCl_2$, and $NaCl$ in various proportions and combinations. Combinations of I_2 plus $CuCl_2$ were less active than either alone. Found Cl_2 action to be retarded by $CuCl_2$ and vice versa. However, Ornstein found that when dilutions of each reduced to about $N/10^6$, a stage in which bactericidal activity of each became additive was reached. The metals Cu and Ag in their test salts showed stages of activity at 2 different dilutions. Combinations of Ag or Cu with I_2 or Cl_2 brought forth this 2-phase characteristic with great regularity. Active zone at higher dilution was widened by small increase of pH. Decreasing concentrations of added $NaCl$ strengthened additively action of Cu or Ag , and in presence of I_2 or Cl_2 , especially at increasing pH.

292. THE PHYSICO-CHEMICAL MECHANISM OF THE OLIGODYNAMIC ACTION OF MERCURY (in French), R. Seigneurin and G. Renoux, Ann. Inst. Past., 69:95 (1943). Investigated oligo. activation of water by Hg . Used diphenylcarbazide as a colorimetric indicator of Hg . Used aq. bidest. in pyrex in presence of baryte, and stored in pyrex flasks. Hg purified by filtering and washing. Colorimetric tests were paralleled by bacteriologic examinations. Relation of temperature and oligo. activation followed approximately the probability curve, with maximum activation at 45 C. Activation of water was proportional to contact period. With 100 cc water contacted by 1 cc Hg : for 19 hours, produced 1.4 ppm Hg in water, which sterilized 22 to 24 million B. Eberth/cc in $1\frac{1}{2}$ hours; 24 hours' contact produced 1.8 ppm Hg and sterilized same bacteria in $1\frac{1}{2}$ hours; 45 hours' contact produced 5.8 ppm Hg and sterilized in $1/2$ hours; 2 months' contact produced 13.0 ppm Hg and sterilized in $1/2$ hour. Activation depended more on Hg -water contact surface area than on Hg volume. Presence of air was factor in activation; increased with presence of O_2 in water. Concluded that activation of water by Hg was chemical phenomenon -- Hg oxidized, then compound dissolved in traces. The water showed alkaline reaction after activation, with pH increase from 6.7 to 7.7.

293. THE SANITATION OF HEAVILY CONTAMINATED WATER SUPPLIES WITHOUT CHLORINATION (in English), Alexander Goetz, Unpublished Report (April 1944). Proposed use of Ag -treated filter-aids, thereby combining filtration and sterilization in one process. Goetz's tests with *E. coli* at 10/cc to 200,000/cc in natural water without artificial additions showed sterilization to be

instantaneous in 95 percent of tests, and sterile in 15 minutes all the time. With 1000 ppm peptone added, *B. coli* in 10 cc was positive once out of 5 tubes immediately after filtration, and all negative 15 minutes after filtration. Concentrations of 100 ppm NH_3 had no inhibitory effect; neither had 25,000 ppm urine.

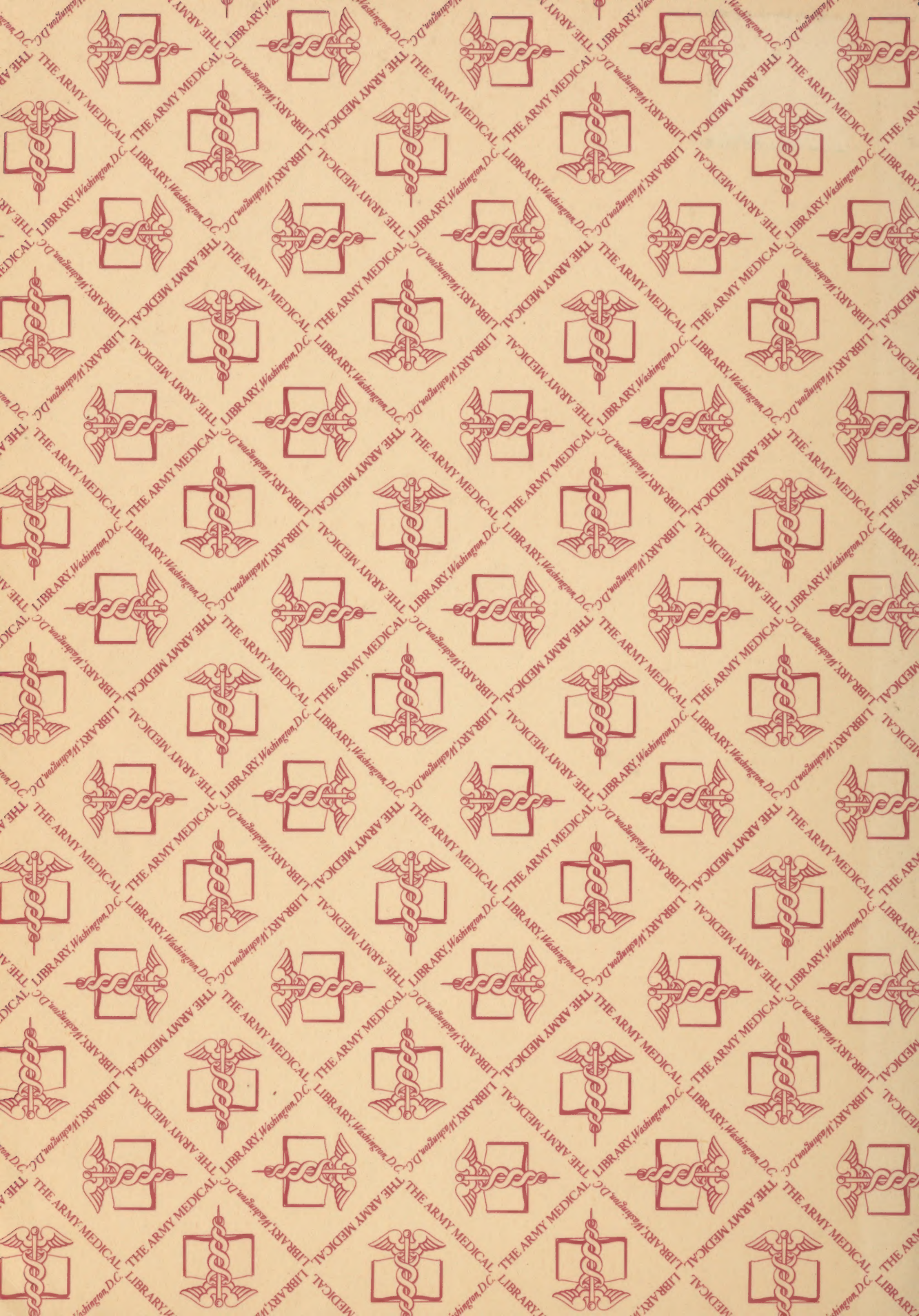
294. PARA-AMINO-BENZENE-SULFONATE OF SILVER. SULF-ARGENTA, A NEW DISINFECTANT (in Spanish), Alberto P. León, Rev. Inst. Salub. Enf. Trop., 6:123 (1945). Described method of preparing sulfargenta. Tested for bactericide of *E. coli* at 100,000/cc in tap water, was bacteriostatic at 0.01 ppm in 6 hours, and at 0.02 ppm in 2 hours.

295. SOME EFFECTS OF METALLIC IONS ON THE METABOLISM OF AEROBACTER AEROGENES (in English), David Perlman, *J. Bact.*, 49:167 (1945). Perlman investigated effects of metal traces on bacterial metabolism. He found obstacle to be lack of bacteriologically complete media which are relatively free of metallic ions. Single passage of medium over cationic exchange material reduced metallic content and enabled prosecution of studies of effects of added metal ions; aq. bidest. treated the same way. Salts cannot be passed through ion-exchanger. Must be supplied highly c.p.

296. STERILIZATION OF WATER SUPPLIES BY THE USE OF SILVER AND ALUMINUM ELECTRODES IN COMBINATION WITH A SAND FILTER (in English), W. J. Marshall, Wat. and Sew., Vol. 84, No. 8 (1946). Combined coagulation, sterilization, and filtration in one unit. Appeared to be Canadian combination of Krause's Electro-Katadyn and of Stuart-Brumley's Electronic Purifier. Aluminum electrode flocculator operates on 6 volt, 3 ampere d-c and provides floc. for sand filter bed. Casing of unit is made cathodic, and floc. built up thereon serves to protect casing and to prevent plating-out of Ag on metal. Ag from electrodes is kept in solution in water and is produced before filtration. Ag ions are trapped in aluminum floc.; no residual-Ag appears in filtrate.

297. SILVER-MANGANESE COATED CANTEEN (in English), Hayse H. Black, Major, CE, U.S.A., from RESTRICTED report, "Technical and Technological Survey, Japanese Military Water Supply Equipment," submitted to Chief of Engineers, War Department, U.S.A. (19 April 1946). Aluminum canteen interior copper plated, Ag-plated, then chemically treated with KMnO_4 gave rapid and effective destruction of bacteria. *B. coli* up to 25,000/cc were reduced to zero in 10 minutes. Typhus, cholera, Shiga, and dysent. Komagome were all sterile in 20 minutes from initial concentrations of 1150 to 24,100/cc. Same in Al non-plated canteens showed only slight reductions after 40 minutes. Water in plated canteen after 1 week

showed slight turbidity, but no objectionable tastes. Presence of H_2S , $NaCl$, or alkali in water produced no interference with oligo. Canteen was effective after one year's use.



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